SIEMENS

SIMATIC

FM 355 closed-loop control module

Operating Instructions

This manual is part of the documentation package with order no: 6ES7355-0VH00-8BA0

Edition 02/2006
A5E00059344-03

Safety Guidelines

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

Danger

indicates that death or severe personal injury **will** result if proper precautions are not taken.

Warning

indicates that death or severe personal injury **may** result if proper precautions are not taken.

Caution

with a safety alert symbol, indicates that minor personal injury can result if proper precautions are not taken.

Caution

without a safety alert symbol, indicates that property damage can result if proper precautions are not taken.

Notice

indicates that an unintended result or situation can occur if the corresponding information is not taken into account.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The device/system may only be set up and used in conjunction with this documentation. Commissioning and operation of a device/system may only be performed by **qualified personnel**. Within the context of the safety notes in this documentation qualified persons are defined as persons who are authorized to commission, ground and label devices, systems and circuits in accordance with established safety practices and standards.

Prescribed Usage

Note the following:

Warning

This device may only be used for the applications described in the catalog or the technical description and only in connection with devices or components from other manufacturers which have been approved or recommended by Siemens. Correct, reliable operation of the product requires proper transport, storage, positioning and assembly as well as careful operation and maintenance.

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Introduction

Preface

Purpose of This Manual

This manual describes all the steps that are required to use the FM 355 function module. It supports rapid and effective familiarization with the FM 355 functionality.

Contents of the Manual

This manual describes the hardware and software of the FM 355. It consists of an instruction section and contains reference material (appendices.)

The following subjects are covered:

- Fundamentals of controlling
- Installing and removing the FM 355
- Wiring the FM 355
- Assigning parameters to the FM 355
- Programming the FM 355
- Appendixes

Target Group

This manual is intended for the following target groups:

- Fitters
- Programmers
- Commissioning engineers
- Service and maintenance personnel

Scope of This Manual

The present manual contains the description of function module FM 355 applicable at the time the manual was published. We reserve the right to describe changes of FM 355 functionality in a Product Information leaflet.

Approvals

The S7-300 has the following approvals:

UL Recognition Mark
Underwriters Laboratories (UL) in accordance with Standard UL 508

CSA-Certification-Mark
Canadian Standard Association (CSA) to Standard C 22.2 No. 142

FM approval complying with Factory Mutual Approval Standard Class Number 3611, Class I, Division 2, Group A, B, C, D

Warning

Personal injury and material damage may be incurred.

In potentially explosive environments, there is a risk of injury or damage if you disconnect any connectors while the S7-300 is in operation.

Always isolate the S7-300 operated in such areas before you disconnect and connectors.

Warning

WARNING - DO NOT DISCONNECT WHILE CIRCUIT IS LIVE UNLESS LOCATION IS KNOWN TO BE NONHAZARDOUS

CE Marking

Our products fulfill the requirements of the EU Directive 89/336/EEC ”Electromagnetic compatibility”.

The EU conformity certificates are available for the relevant authorities and are kept at the following address in accordance with the above-mentioned EU Directive. Article 10:

Siemens Aktiengesellschaft
Bereich Automatisierungs- und Antriebstechnik
A&D AS RD ST PLC
Postfach 1963
D-92209 Amberg

Position in the Information Landscape

This manual is a component of the S7-300 and ET 200M documentation.

System	Documentation
S7-300	• *S7-300 Automation systems Structure, CPU Data* • *S7-300, M7-300 Automation systems, Module specifications* • *S7-300 Operation List*
ET 200M	• *ET 200M Distributed I/O Device* • *S7-300, M7-300 Automation systems, Module Specifications*

Guide

The manual contains the following guides which provide quick access to the specific information you need:

- At the beginning of the manual you can find a comprehensive list of contents.
- Following the appendices, you will find a glossary in which important technical terms used in the manual are defined.
- The manual closes with a list of references and a detailed index for quick access to the information you require.

Further Support

If you have any questions concerning the use of products which are not answered in this manual, please contact your local Siemens partner at your Siemens office. A list of Siemens representatives worldwide is contained, for example, in the appendix entitled "Siemens Worldwide" of the manual "S7-300 Automation systems, Configuration of an S7-300.

We offer a range of courses to help get you started with the SIMATIC S7 programmable controller. Please contact your local training center or the central training center in Nuremberg, D-90327 Germany, Tel. +49 (0) 911 895 3200.

Up-to-the-minute Information

The SIMATIC Customer Support offers you extensive additional information on the SIMATIC products via the on-line services:

- You can obtain general current information:
  - On the **Internet** at `http://www.ad.siemens.de/simatic`
- Current product information and downloads as an additional help:
  - On the **Internet** at `http://www.ad.siemens.de/simatic-cs`
  - Via the **Bulletin Board System** (BBS) in Nuremberg (*SIMATIC Customer Support Mailbox)* under +49 (911) 895-7100.

    To dial the mailbox, use a modem with up to V.34 (28.8 Kbps), with the following parameter settings: 8, N, 1, ANSI, or dial via ISDN (x.75, 64 Kbps).

Nuremberg **SIMATIC BASIC Hotline**	**Johnson City** **SIMATIC BASIC Hotline**	**Singapore** **SIMATIC BASIC Hotline**
Local time: M - F 7:00 a.m. to 5:00 p.m. Phone: +49 (180) 5050-222 Fax: +49 (180) 5050-223 Email: techsupport@ ad.siemens.de GMT: +1:00	Local time: M - F 8:00 a.m. to 5:00 p.m. Phone: +1 423 461-2522 Fax: +1 423 461-2231 Email: simatic.hotline@ sea.siemens.com GMT: –5:00	Local time: Mo.-Fr. 8:30 to 17:30 Phone: +65 740-7000 Fax: +65 740-7001 Email: simatic.hotline@ sae.siemens.com.sg GMT: +8:00
Nuremberg SIMATIC authorization hotline	**SIMATIC Premium Hotline** (fee based, only with SIMATIC Card)	
Local time: M - F 7:00 a.m. to 5:00 p.m. Phone: +49 (911) 895-7200 Fax: +49 (911) 895-7201 Email: authorization@ nbgm.siemens.de GMT: +1:00	Time: Mon.-Fri. 0:00 to 24:00 Phone: +49 (911) 895-7777 Fax: +49 (911) 895-7001 GMT: +1:00	
The languages of the SIMATIC Hotlines are generally German and English, in addition, French, Italian and Spanish are spoken on the authorization hotline.		

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Tables

1 Product Overview

1.1 Introduction

Variants of the FM 355

The FM 355 is available in the following 2 variants:

- Continuous-action controller with analog outputs
- S controller (step and pulse controllers with digital outputs)

Order Numbers

Product	Scope of delivery	Order Number
FM 355 C	• FM 355 C module, version $\geq$ 6 (continuous controller) • CD with configuration package, manual and Getting Started	6ES7355-0VH10-0AE0
FM 355 S	• FM 355 S module, version $\geq$ 6 (step and pulse controller) • CD with configuration package, manual and Getting Started	6ES7355-1VH10-0AE0

1.2 Functionality of the FM 355

Introduction

The FM 355 function module is a controller module for use in the S7-300 Automation systems.

Control Method

Two different control methods are implemented in the FM 355. Support in optimizing the control system is available for both control methods:

Control method	Optimization by ...
Temperature controller (fuzzy controller)	... The module (self-tuning controller)
PID controller	... Parameter assignment interface or PID Self Tuner

Control Structures

You can use the FM 355 for the following control structures:

- Set-value control
- Follower control
- 3-component control
- Cascade control
- Ratio control
- Mix control
- Split-range control

Operating modes

The FM 355 can operate in the following modes:

- Automatic
- Manual
- Safety mode
- Follow-up control mode (changeover to preset safety value)
- Specification of the manipulated value DDC (Direct Digital Control)
- Follow-up/SPC controller (SPC = Set Point Control)
- Back-up mode (at CPU in STOP or CPU failure)

Number of Channels

The FM 355 contains 4 controllers operating independently of each other in 4 channels.

Number of Inputs and Outputs

The following table provides an overview of the number of inputs and outputs of the FM 355.

Table 1-1 Inputs and outputs of the the FM 355

Inputs/Outputs	FM 355 C	FM 355 S
Analog inputs	4	4
Digital inputs	8	8
Analog outputs	4	-
Digital outputs	-	8

Diagnostics Interrupt

The FM 355 can trigger a diagnostics interrupt if any of the following occur:

- Error in module parameterization
- Module defective
- Overflow and underflow at analog inputs
- Load break and short circuit at analog outputs

Hardware Interrupts

Hardware interrupts are not required for FM 355 operation.

Reference Junction

For operation with thermocouples the FM 355 has an additional analog input for connecting a Pt100 in 4-wire design. This input is used to measure the reference junction temperature and thus to carry out compensation at thermocouples.

Parameterization

The FM 355 can be parameterized by means of a parameter configuration interface.

1.3 Areas of Application for the FM 355

Where Can You Use the FM 355?

The FM 355 is a universally applicable controller module for the following control tasks:

- Temperature control
- Level control
- Filling level control
- Pressure control
- Flow control
- Concentration control

Applications

The FM 355 is usually used to carry out control tasks in the following branches:

- General machine construction
- Plant construction
- Industrial furnace construction
- Cooling and heating unit construction
- Food and beverage industry
- Process engineering
- Environmental technology
- Glass and ceramics manufacturing
- Rubber and plastics machines
- Woodworking and paper industry

1.4 FM 355 Hardware

Module View

The following figure shows the FM 355 module with front connectors and the bus connector at closed front doors.

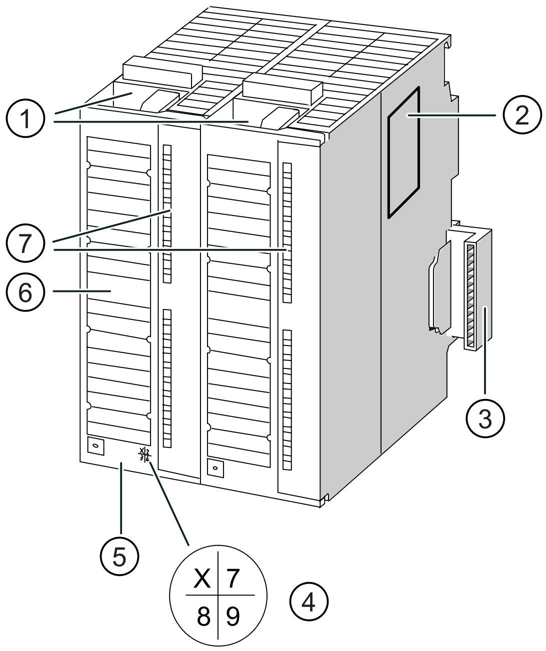


Figure 1-1 FM 355 module view

①	Front connector with front connector coding
②	Type plate
③	SIMATIC interface bus connector
④	Version
⑤	Order Number
⑥	Labeling strips
⑦	LEDs

Front Connectors

The FM 355 offers the following connection possibilities via the front connectors:

- 8 digital inputs
- 4 analog inputs
- 1 reference junction input
- 8 digital outputs (only step controllers)
- 4 analog outputs (only continuous-action controllers)
- Supply voltage 24 V DC between L+ and M to supply the module and the digital and analog outputs
- Reference point of the analog circuit M_{ANA}

The front connectors must be ordered separately (refer to the "Spare Parts" appendix).

Front Connector Coding

When you press a front connector from the wiring position to the operating position, the front connector coding engages. Thereafter, this front connector can only be attached to an FM 355 module.

Labeling strips

Enclosed with the module are two labeling strip on which you can write your signal names individually.

The corresponding pin assignments are printed on the insides of the front panel.

Order Number and Version

The order number and the version of the FM 355 are given at the bottom of the left-hand front panel.

Bus Connectors

The communication within a row of the S7 300 takes place via the bus connector. The bus connector is enclosed with the FM 355.

Diagnostics and Status LED's

The FM 355 has ten LEDs that can be used both for diagnostics and for indicating the status of the FM 355 and its digital inputs.

The following table lists the LEDs with their labeling, color and function.

Table 1-2 Diagnostics and Status LED's

Labeling	Color	Function
SF	red	Group error
Backup	Yellow	Display of the backup mode
I1	Green	Status of Digital Input I1
I2	Green	Status of Digital Input I2
I3	Green	Status of Digital Input I3
I4	Green	Status of Digital Input I4
I5	Green	Status of Digital Input I5
I6	Green	Status of Digital Input I6
I7	Green	Status of Digital Input I7
I8	Green	Status of Digital Input I8

The LEDs next to the binary outputs of the FM 355 S are not controlled and do not have any meaning.

1.5 FM 355 Software

Software Package of the FM 355

In order to integrate the FM 355 in the S7-300 you require a software package with:

- Parameter configuration interface
- Software for the CPU (function blocks)

Parameter Configuration Interface

The FM 355 is adapted to the task in hand via parameters. These parameters are stored in the system data and are transferred in the CPU STOP state from the programming device/PC to the CPU and to the FM 355. In addition the CPU transfers these parameters to the module during every transition from STOP to RUN.

You can specify the parameters via the parameter configuration interface. The parameter configuration interface is installed on your programming device/PC and called up within STEP 7.

Online Help

Further information about the parameter configuration is available in the integrated online help.

Software for the S7-300 CPU (Function Blocks)

The software for the CPU consists of the function blocks:

- PID_FM for modifying parameters and operating modes (e.g. setpoint, manual to automatic changeover) during running operation and to read out process states (e.g. actual value).
- FORCE355 for forcing analog and digital inputs during commissioning (forcing = specify simulation values).
- READ_355 for reading out the analog and digital input values during commissioning.
- CH_DIAG for reading out channel-specific diagnostic values during commissioning.
- FUZ_355 for reading out the parameters of the self-tuning temperature controller (fuzzy controller) for loading these parameters to the FM 355 (e.g. at a module replacement without renewed parameter identification of the controller).
- PID_PAR for special applications for changing further parameters during running operation.

The following figure shows an S7-300 configuration with an FM 355 and several signal modules.

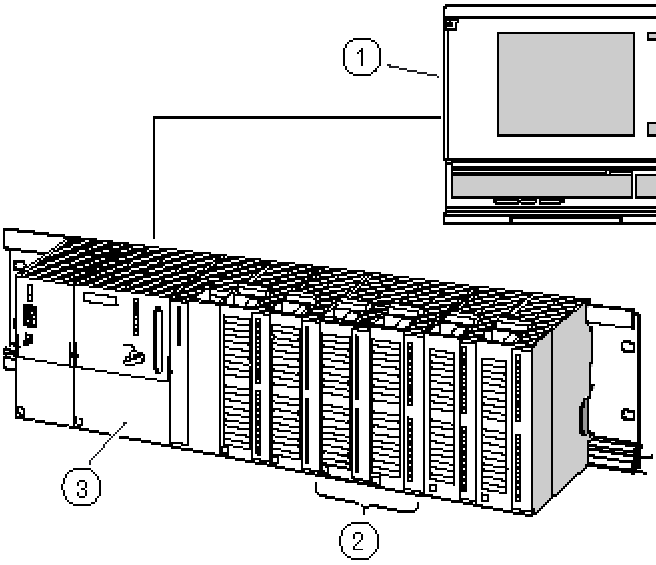


Figure 1-2 SIMATIC S7-300 configuration with an FM 355

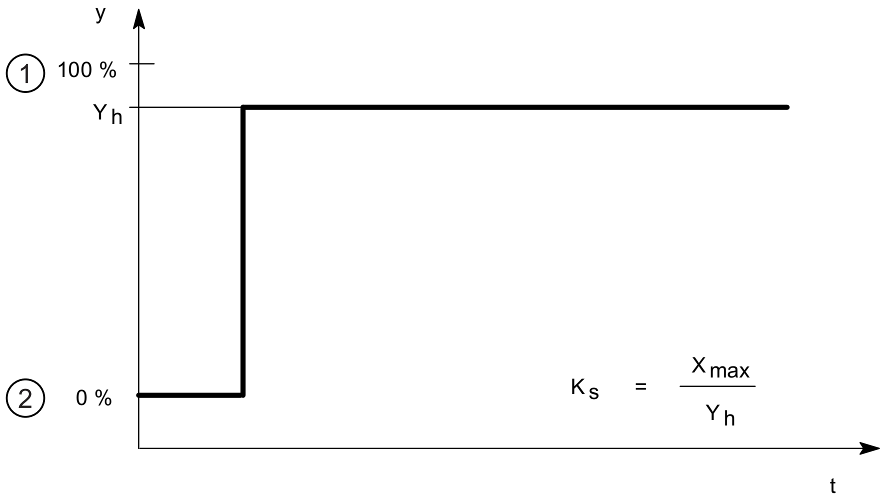
① Programming device (PG) with STEP 7 and the parameter configuration masks
② FM 355
③ CPU with application program and FBs of the FM 355

2 Information for the controller adjustment

2.1 Characteristic Values of the Controlled System

Determining the Time Response from the Step Response

Time response of the controlled system can be determined by the time sequence of Controlled variable x after an abrupt change of Manipulated variable y from 0 to 100%.



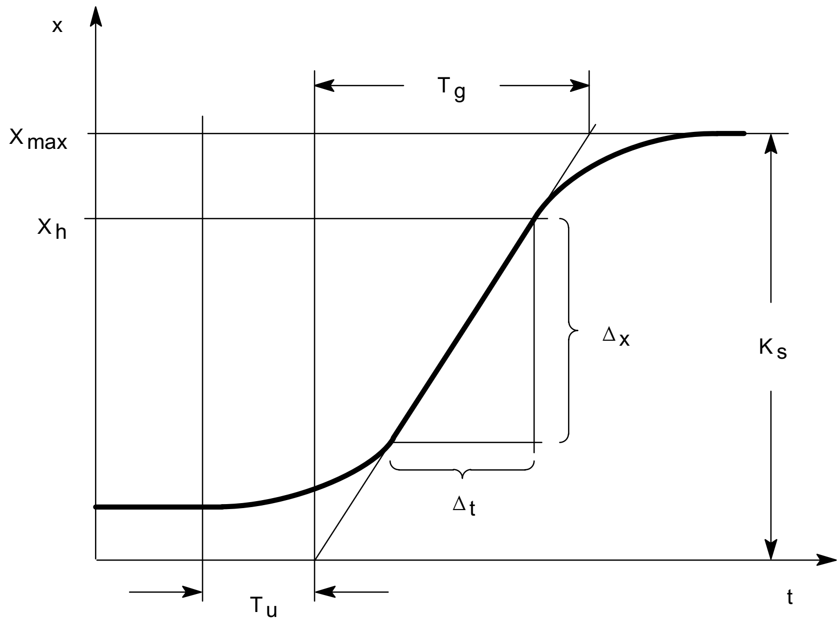


Figure 2-1 Step response of a controlled system

① 100% ON

② 0% OFF

Most of the controlled systems are so-called controlled systems with self-regulation (refer to the figure above).

The time response can be determined by approximation using the variables Delay time T_u, Recovery time T_g and Maximum value X_{max}. The variables are determined by applying tangents to the maximum value and the inflection point of the step response. Recording the transition function up to the maximum value is not possible in many cases because the controlled variable may not exceed certain values. The rate of rise v_{max} is therefore used for the controlled system.

From the ratio

T_u / T_g or T_u x v_{max} / X_{max}

it is possible to estimate the suitability of the controlled system for controlling. The following applies:

T_u / T_g	Suitability of the controlled system for controlling
< 0,1	can be controlled well
0.1 to 0.3	can still be controlled
> 0,3	difficult to control

Controlled systems can be judged on the basis of the following values:

T_u < 0.5 min, T_g < 5 min = fast controlled system

T_u > 0.5 min, T_g > 5 min = slow controlled system

Characteristic values of important temperature controlled systems

Controlled variable	Type of controlled system	Delay time T_u	Recovery time T_g	Rate of rise v_{max}
Temperature	Small electrically heated furnace	0.5 to 1 min	5 to 15 min	Up to 60 K/min.
	Large electrically heated annealing furnace	1 to 5 min	10 to 20 min	Up to 20 K/min.
	Large gas-heated annealing furnace	0.2 to 5 min	3 to 60 min	1 to 30 K/min
	Autoclaves	0.5 to 0.7 min	10 to 20 min	
	High-pressure autoclaves	12 to 15 min	200 to 300 min	
	Injection molding machines	0.5 to 3 min	3 to 30 min	5 to 20 K/min
	Extruders	1 to 6 min	5 to 60 min	
	Packaging machines	0.5 to 4 min	3 to 40 min	2 to 35 K/min

2.2 Controller Types (Two-Step, Three-Step Controllers)

Two-Step Controllers Without Feedback

Two-step controllers have the state "ON" and "OFF" as the switching function. This corresponds to 100% or 0% output. Through this behavior a sustained oscillation of Controlled variable x occurs around Setpoint value w.

The amplitude and the oscillation duration increases with the ratio of the Delay time T_u to the Recovery time T_g of the controlled system. These controllers are used mainly for simple temperature control systems (such as electrically directly heated furnaces) or as limit-value signaling units.

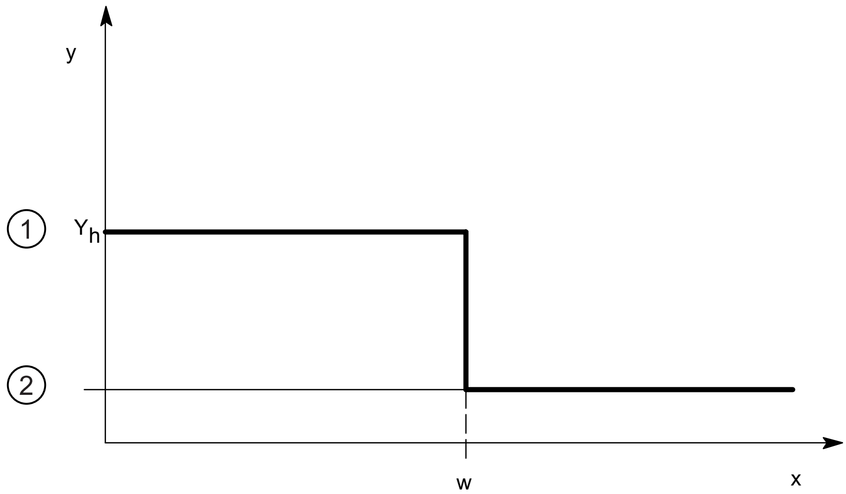


Figure 2-2 Characteristic curve of a two-step controller

①	ON
②	OFF
Y_h	Position range
w	Reference value

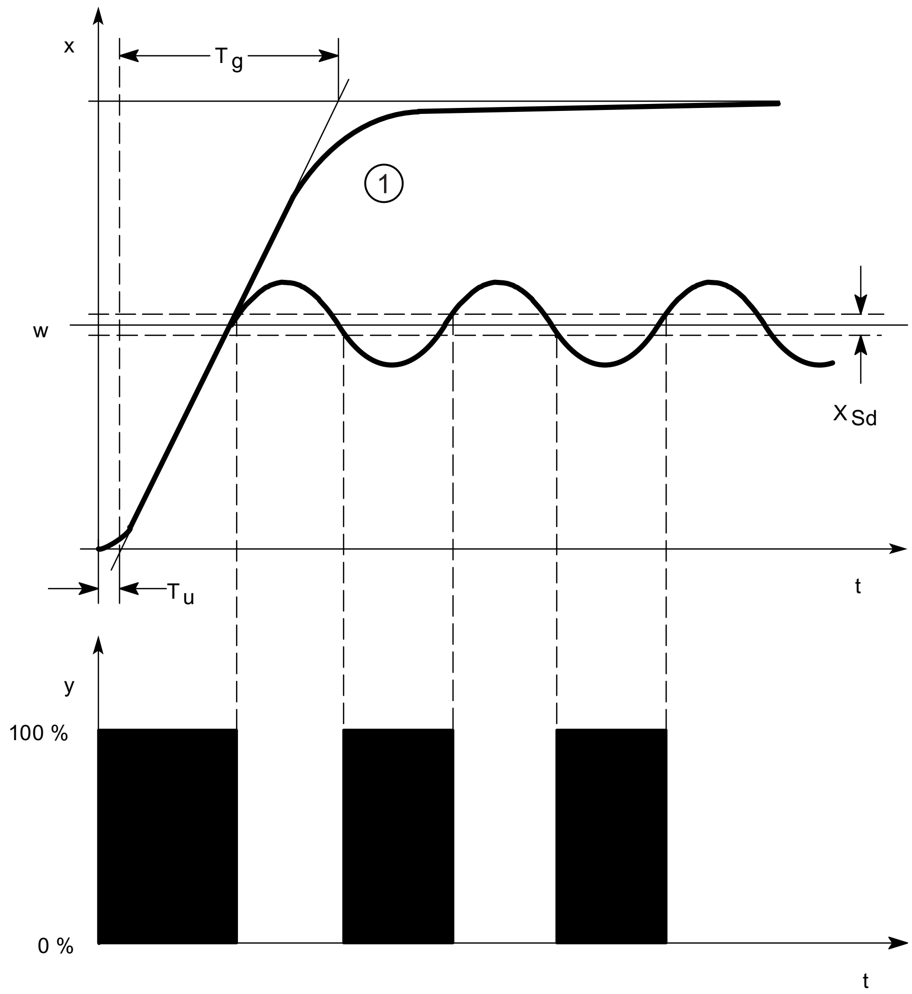


Figure 2-3 Control function of a two-step controller without feedback

①	Transition function without controller
T_u	Delay time
T_g	Recovery time
X_{Sd}	Switching difference

Two-Step Controllers With Feedback

The behavior of two-step controllers at controlled systems with high delay times, e.g. furnaces at which the utilization room is separated from the heating, can be improved through electronic feedbacks.

The feedback is used to increase the switching frequency of the controller, thus reducing the amplitude of the controlled variable. In addition, the control-action results can be improved substantially in dynamic operation. The limit for the switching frequency is set by the output level. It should not exceed 1 to 5 switches per minute at mechanical actuators, such as relays and contactors. In the case of voltage and current outputs with downstream thyristor or Triac controllers high switching frequencies can be selected that exceed the limit frequency of the controlled system by far.

Since the switching pulses can no longer be determined at the output of the controlled system, results comparable with those of continuous controllers are obtained.

In contrast to a continuous controller, at which the amplitude of the output signal represents the manipulated variable, the output variable is formed at a two-step controller with feedback through pulse width modulation.

Two-step controllers with feedback are used for temperature control in furnaces, at processing machines in the plastics, textile, paper, rubber and foodstuff industries as well as for heating and cooling devices.

Three-Step Controllers

Three-step controllers are used for heating/cooling. These controllers have 2 switching points as their output. The control-action results are optimized through electronic feedback structures. Fields of applications for such controllers are heating, low-temperature, climatic chambers and tool heating units for plastic-processing machines.

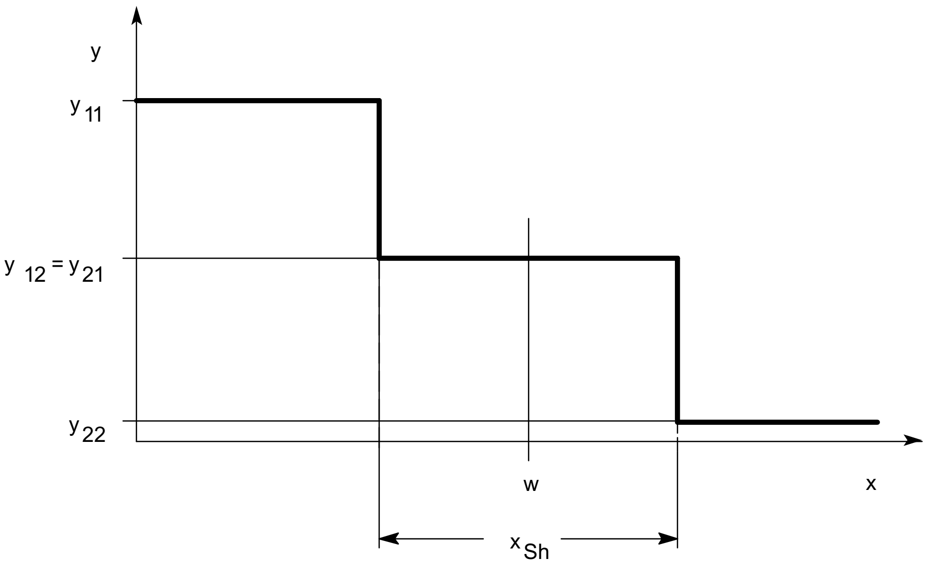


Figure 2-4 Characteristic curve of a three-step controller

y	Manipulated variable, e.g. y_{11} = 100% heating y_{12} = 0% heating y_{21} = 0% cooling y_{22} = 100% cooling
x	Controlled variable, e.g. temperature in °C
w	Setpoint
x_{Sh}	Distance between Switching Point 1 and Switching Point 2

2.3 Control Response at Different Feedback Structures

Control Behavior of Controllers

In order to achieve the precision of a control system and optimal disturbance correction an adaptation of the controller to the time response of the controlled system is required.

Feedback structures are used to this purpose. Depending on the feedback circuit structure this can have a proportional action (P), proportional-derivative action (PD), proportional-integral action (PI) or proportional-integral-derivative action (PID). If a jump function to the controller input exists, jump responses arise under the condition that the delay times of the controller are negligibly small and that the controller reacts very rapidly.

P-action Controller

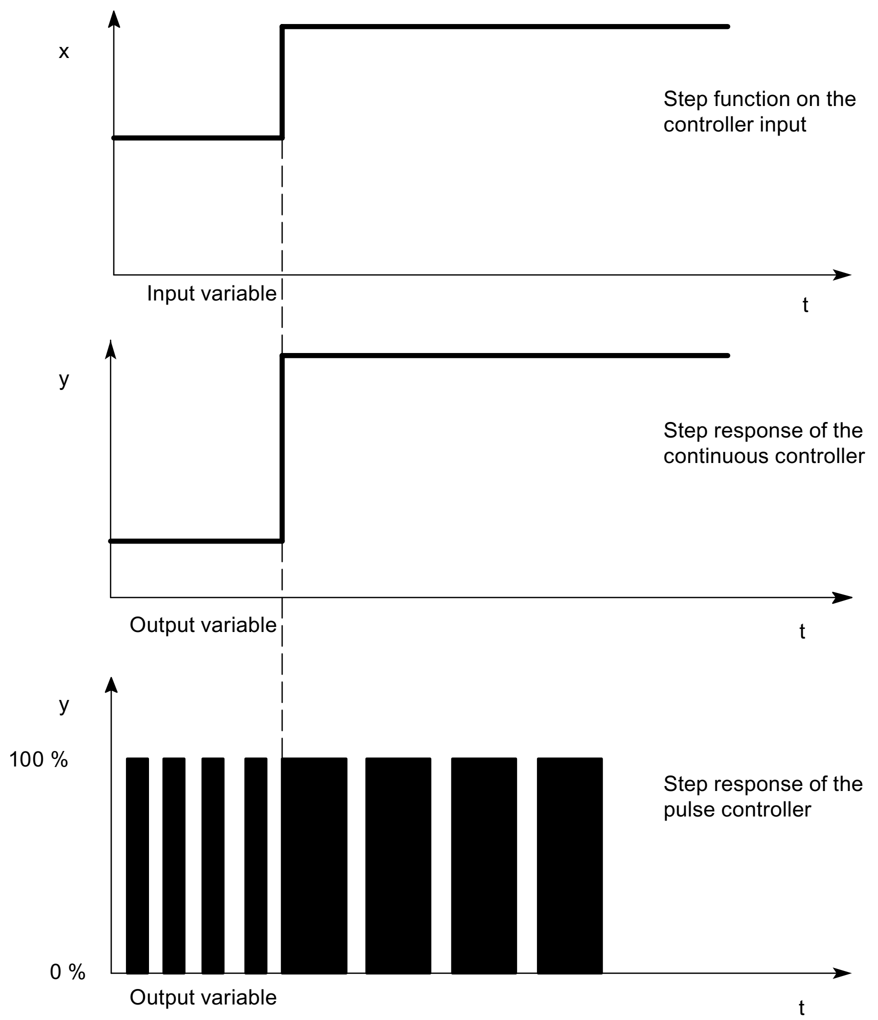


Figure 2-5 The jump response of a P-action controller

Equation for P-action controller

Output variable and input variable are directly proportional, meaning:

Output variable change = Proportional-action gain x Input variable change, or

$y = GAIN \times x_w$

PD-action controller

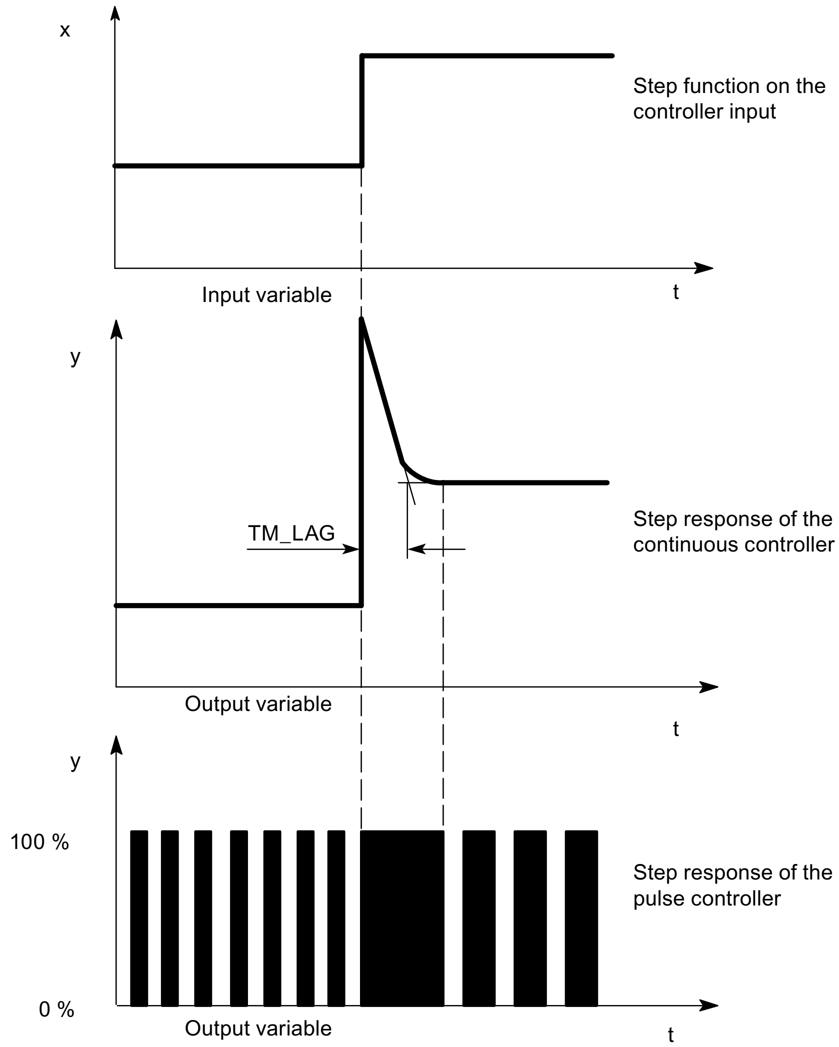


Figure 2-6 Jump response of a PD-action controller

D-action control elements are not suitable on their for controlling, since they no longer emit an actuating command when the input variable has settled back to a static value.

In combination with P-action control elements the derivative component is used to generate a corresponding control pulse depending on the change speed of the controlled variable

If a Disturbance x acts on the controlled system, the PD-action controller sets a different system deviation due to the changed degree of correction. Disturbances are not corrected completely. The good dynamic response is advantageous. A well attenuated, non-oscillating transition is achieved during starting up and the reference input variable. However, a controller with D-action is not appropriate if a controlled system has pulsing measured quantities, for example at pressure or flow control systems.

Equation for PD-action controller

The following applies for the jump response of the PD-action controller in the time range:

$$y = GAIN \times x_W \times \left(1 + \frac{TD}{TM\_LAG} \times e^{\frac{-t}{TM\_LAG}} \right)$$

t = Duration since the jump of the input variable

PI-action Controller

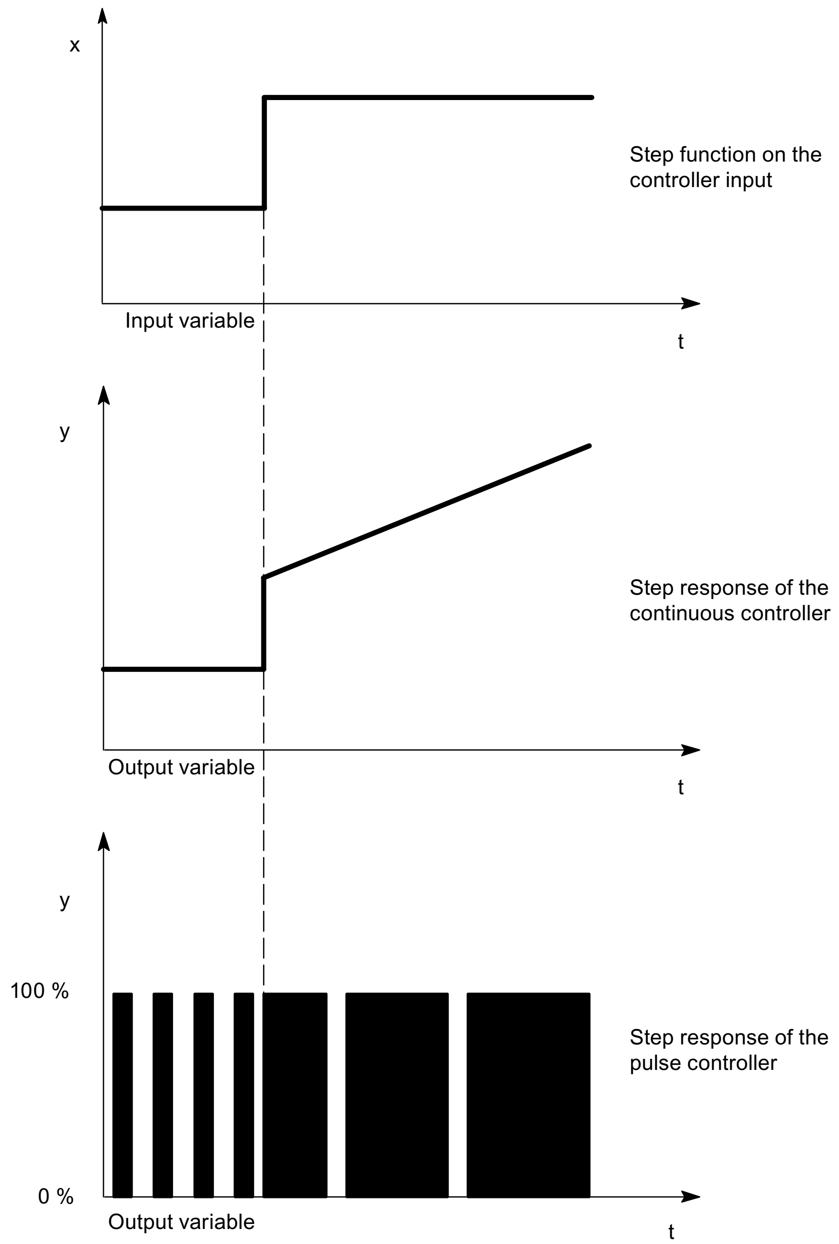


Figure 2-7 Jump response of a PI-action controller

I-action control elements have the integral of the input variable as the output variable, i.e. the controller totals the deviation from the setpoint value for the duration. This means that the controller continues to adjust until the deviation from the setpoint value has been eliminated.

In practical experience a combination of the various timing elements is ideal, depending on the requirements placed on the control response. The time response of the individual elements can be described by the controller parameters Proportional band GAIN, Reset time TI (I-action) and Differential-action time TD (D-action).

Equation for PI-action controller

The following applies for the jump response of the PI-action controller in the time range:

$$y = GAIN \times x_w \times \left(1 + \frac{1}{TI \times t} \right)$$

t = Duration since the jump of the input variable

PID-action Controller

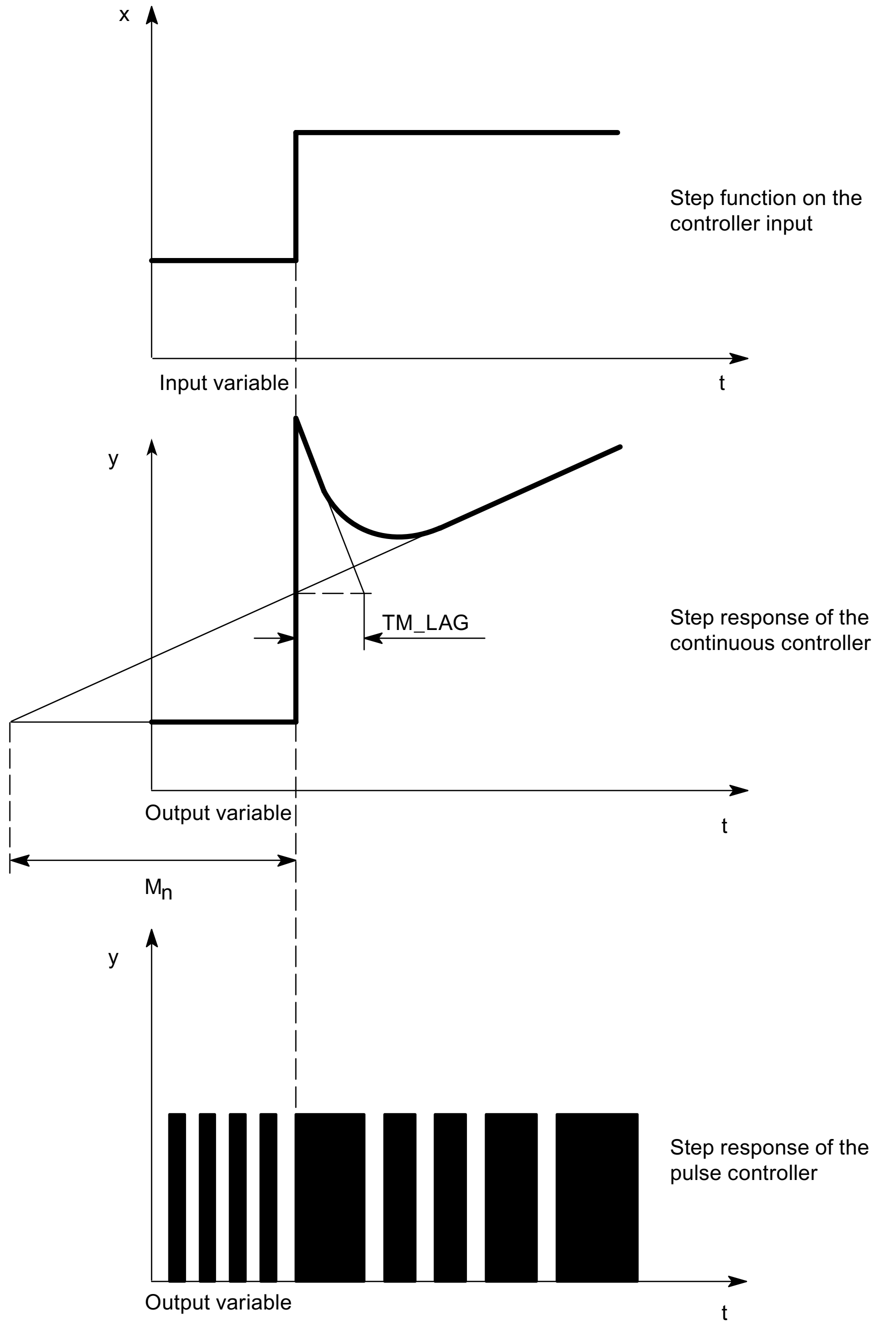


Figure 2-8 Jump response of a PID-action controller

Most of the controller systems occurring in process engineering can be controlled by means of a controller with PI-action response. In case of slow controlled systems with a high delay time, for example temperature control systems, the control-action results can be improved by a controller with PID action.

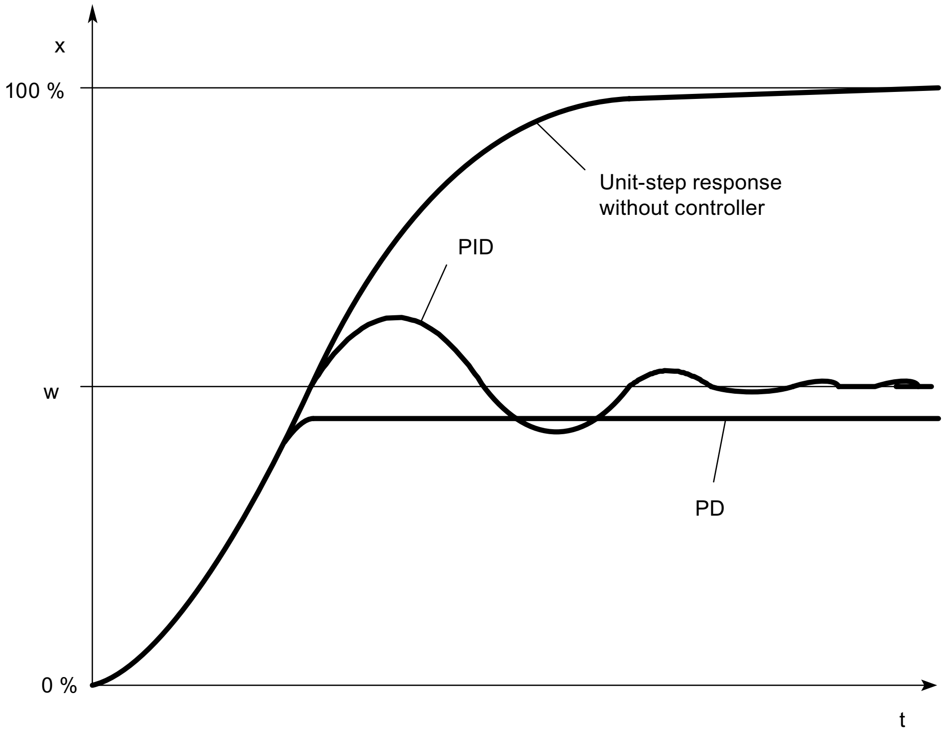


Figure 2-9 Jump response at various control responses

Controllers with PI and PID action have the advantage that the controlled variable does not have any deviation from the setpoint value after settling. The controlled variable oscillates over the setpoint value during starting up.

Equation for PID-action controller

The following applies for the jump response of the PI-action controller in the time range:

$$y = GAIN \times x_W \times \left(1 + \frac{1}{TI \times t} + \frac{TD}{TM\_LAG} \times e^{\frac{-t}{TM\_LAG}} \right)$$

t = Duration since the jump of the input variable

2.4 Choosing the controller structure with a given control section

Selection of the Suitable Controller Structures

Amongst the closed-control elements the controlled systems have a special position. Their properties are determined by the process-specific applications and cannot be changed afterwards. An optimal control-action result can thus only be achieved by the selection of a suitable controller whose response can be adapted to the system data within certain limits.

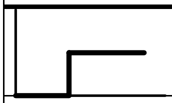
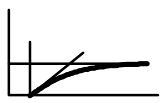
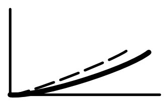
Controlled system		Controller structure			
		P	PD	PI	PID
	Pure dead time	Unusable	Unusable	**Control + disturbance**	Unusable
	Dead time + first-order time-delay	Unusable	Unusable	Slightly worse than PID	**Control + disturbance**
	Dead time + second-order time-delay	Not suitable	Bad	Worse than PID	**Control + disturbance**
	Order + very small dead time (delay time)	**Control**	Control at delay time	**Disturbance**	Disturbance at delay time
	Higher order	Not suitable	Not suitable	Slightly worse than PID	Control + disturbance
	Not self-regulating	Control (without delay)	Control (with delay)	Control (without delay)	Control (with delay)

Table 2-1 Suitable Controller for the Most Important Control Variables

Controller	P	PD	PI	PID
Controlled variable	Steady-state control deviation		No steady-state control deviation	
Temperature	for less demands and with P sections with T_u / T_g < 0.1	Well suited	The most suitable controller types for high-quality requirements (except for specially adapted special controllers)	
Pressure	Suitable, if the delay time is inconsiderable	Unsuitable	The most suitable controller types for high-quality requirements (except for specially adapted special controllers)	
Flow rate	If suitable, because required GAIN range usually too large	Unsuitable	Suitable, but I-action controller alone often better	Hardly required for these control variables

2.5 Setting the Controller Characteristic Values (Optimization)

Rule of Thumb for the Parameter Setting

Controller structure	Setting
P	GAIN ≈ v_{max} x T_u [°C]
PI	GAIN ≈ 1.2 x v_{max} x T_u [°C]
PD	GAIN ≈ 0.83 x v_{max} x T_u [°C] TD ≈ 0.25 x v_{max} x T_u [min] TM_LAG ≈ 0.5 x TD[min]
PID	GAIN ≈ 0.83 x v_{max} x T_u [°C] TI ≈ 2 x T_u [min] TD ≈ 0.4 x T_u [min] TM_LAG ≈ 0.5 x TD[min]
PD/PID	GAIN ≈ 0.4 x v_{max} x T_u [°C] TI ≈ 2 x T_u [min] TD ≈ 0.4 x T_u [min] TM_LAG ≈ 0.5 x TD[min]

Instead of $V_{max} = \Delta_x / \Delta_t$ you can use X_{max} / T_g.

In the case of controllers with PID structure the setting of the reset time and differential-action time is usually coupled with each other.

The ratio TI / TD lies between 4 and 5 and is optimal for most control systems.

Non-observance of the differential-action time TD is uncritical at PD controllers.

In the case of PI and PID controllers, control oscillations occur if the reset time TI has been select by more than half too small.

A reset time that is too large slows down the settling times of disturbances. One cannot expect that the control loops operate "optimally" after the first parameter settings. Experience shows that adjusting is always necessary, when a system exists that is "difficult to control" with $T_u / T_g > 0.3$.

Feedbacks and Controlled Systems

Controlled variable	Type of controlled system	T_u or T_t [1]	T_g or T_s [2]	$V_{max.} = \Delta x / \Delta t$
Temperature	Small electrically heated furnace	0.5 to 1 min	5 to 15 min	1 °C/s
	Large electrically heated annealing furnace	1 to 5 min	10 to 60 min	0.3 °C/s
	Large gas-heated annealing furnace	0.2 to 5 min	3 to 60 min	
	Distillation tower	1 to 7 min	40 to 60 min	0.1 to 0.5 °C/s
	Autoclave (2.5 m^3)	0.5 to 0.7 min	10 to 20 min	
	High-pressure autoclave (1000°C, 40 bar)	12 to 15 min	200 to 230 min	
	Steam superheater	30 s to 2.5 min	1 to 4 min	2°C/s
	Room heating	1 to 5 min	10 to 60 min	1°C/min.
Flow rate	Pipeline with gas	0 to 5 s	0.2 to 10 s	–
	Pipeline with liquid	0	0	
Pressure	Gas pipeline	0	0.1 s	–
	Drum boiler with gas or oil firing	0	150 s	–
	Drum boiler with impact grinding mills	1 to 2 min	2 to 5 min	–
Vessel level	Drum boiler	0.6 to 1 min	–	0.1 to 0.3 cm/s
Speed	Small electric drive	0	0.2 to 10 s	–
	Large electric drive	0	5 to 40 s	–
	Steam turbine	0	–	50 min^{-1}
Voltage	Small generators	0	1 to 5 s	–
	Large generators	0	5 to 10 s	–

[1] T_t = Dead time

[2] T_S = section constants

2.6 Determining the System Parameters for Two-/Three-Step Controllers

Procedure

You can record the heating and cooling behavior of the temperature controlled systems by means of a recording unit (see figure below). To do this, proceed as follows:

1. Specify the programming device manipulated value 0 via the loop monitor.
2. Configure the controller as a PI controller.
3. Enter uncritical control parameters via the parameter configuration interface or the PID_FM FB:

   GAIN = 1.0

   TI, TD = 0.0
4. Load the parameters to the module.
5. Switch to the manipulated value controller via the loop monitor.
6. Enter the setpoint temperature (1).

The module switches on the heating.

7. Wait until the process value has "settled" (2).

Remark: The setpoint value does not have to be reached.

8. Specify the setpoint temperature 0 °C. (3).

   The module switches on the cooling.

Remark: Steps 7 and 8 are only required at three-step controllers.

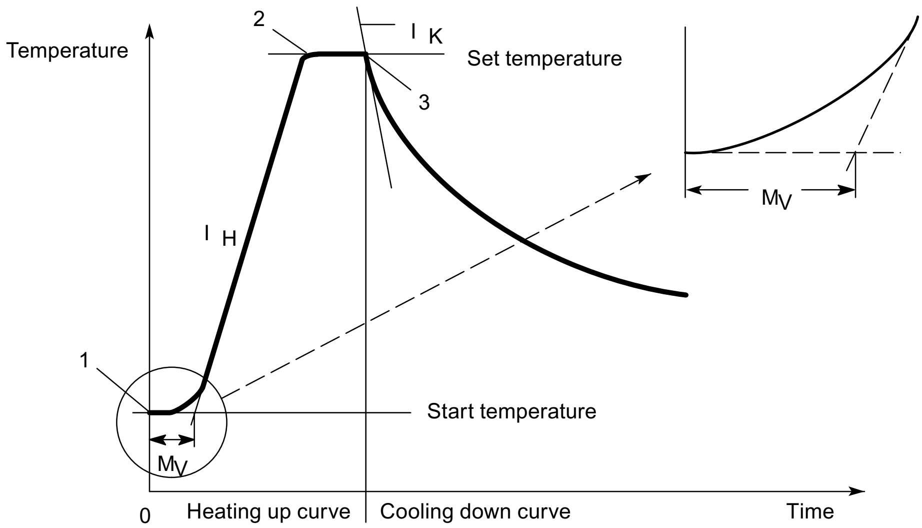


Figure 2-10 Determined heating and cooling curve

You can then determine the following parameters from the curve:

T_U = Delay time (in s)

S_K = Maximum ascent of the cooling curve (in °C/s)

S_K = Maximum ascent of the heating curve (in °C/s)

Determining the Controller Parameters

a) T_A [ms] = The sampling time

T_A is determined by the conversion time of the FM 355. You can read off the T_A in the parameter configuration interface:

Button: **Module parameters**

b) GAIN = $$\frac{230\ [°C]}{S_H \left[\frac{°C}{s}\right] \times \left(T_U[s] + \frac{T_A[ms]}{2000\left[\frac{ms}{s}\right]} \right)}$$

c) $T_I[s]$ = $$\left(T_U[s] + \frac{T_A[ms]}{1000\left[\frac{ms}{s}\right]} \right) \times 6{,}66 \left[\frac{s}{s}\right]$$

d) $T_D[s]$ = $$\left(T_U[s] + \frac{T_A[ms]}{1000\left[\frac{ms}{s}\right]} \right) \times 0{,}6$$

In addition at three-step controllers:

e) LMN_LLM = $$\frac{S_K\left[\frac{°C}{s}\right]}{S_H\left[\frac{°C}{s}\right]} \times (-100\ [\%])$$

LMN_LLM is a parameter of the PID_FM FB. It specifies the lower limit of the controller.

You can set this value at the "Lower" parameter in the **Limit manipulated value controller** mask of the parameter configuration interface.

You have to set the same value at the "Start of range input signal" parameter of manipulated value B in the **Split-range controller** mask.

The two settings have to agree so that the input value of the split-range function of the controller can take on values from the full setting range of the slit-range function.

Example

Manipulated variable	0 %	up to	100 %	Corresponds to heating
Manipulated variable	- 100 %	up to	0 %	Corresponds to cooling

Set the parameters of the split-range function as follows for this example:

- Manipulated value A:
  - Start of range input signal = 0
  - End of range input signal = 100
  - Start of range output signal = 0
  - End of range output signal = 100
- Manipulated value B:
  - Start of range input signal = -100
  - End of range input signal = 0
  - Start of range output signal = 100
  - End of range output signal = 0

2.7 Determining the System Parameters for Pure Cooling Controllers

Procedure

You can record the cooling-down behavior of the temperature controlled system by means of a recording unit (see figure below).

To do this, proceed as follows:

1. Enter uncritical control parameters:

   GAIN = 1.0

   T_I, T_D = 0.0
2. Set the manipulated value to manual operation
3. Specify the manipulated value 0 via the loop monitor.
4. Let the temperature "settle" to the operating temperature by feeding external heating energy (for example through adjacent heating zones).
5. Specify the setpoint temperature 0°C via the loop monitor (1).
6. Set the manipulated value to controller operation.

   → The module switches on the cooling.

Note

During the cooling-down process the external heating energy supply must remain constant. For example, the adjacent heating zones have to be heated with a constant manipulated variable.

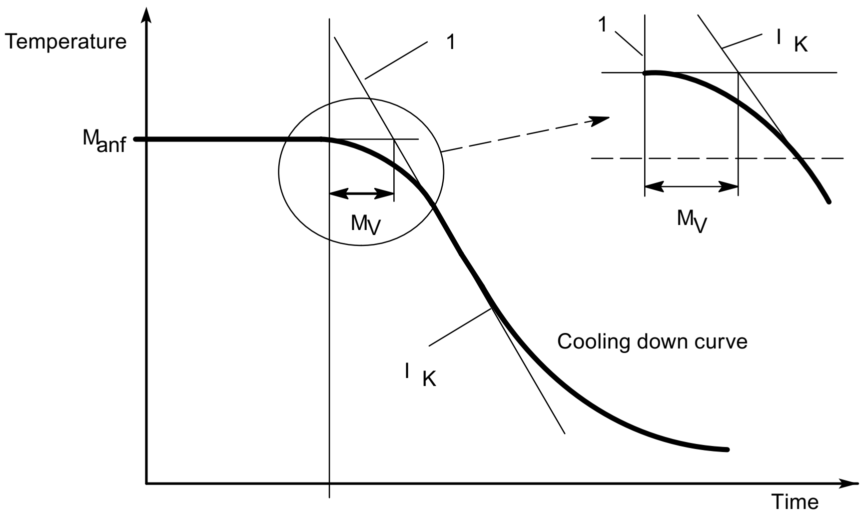


Figure 2-11 Determined cooling-down curve

- You can then determine the following parameters from the curve:

T_U = Delay time (in s)

S_K = Maximum ascent of the cooling curve (in °C/s)

T_{ini} = Initial temperature (in °C)

- In addition, the temperature T_{Cool} (in °C) of the cooling medium has to be determined.

Determining the controller parameters

a) T_A [ms] = The sampling time
T_A is determined by the conversion time of the FM 355. You can read off the
T_A in the parameter configuration interface: Button: **Module parameters**

b) GAIN of 200°C =

$$\frac{230\,[\,°C\,]}{S_K\left[\frac{°C}{s}\right] \times \frac{200\,°C - T_{KÜHL}[°C]}{T_{anf}[°C] - T_{KÜHL}[°C]} \times \left(T_U[\,s\,] + \frac{T_A[ms\,]}{2000\left[\frac{ms}{s}\right]}\right)}$$

c) T_N[s] =

$$\left(T_U[\,s\,] + \frac{T_A[ms\,]}{1000\left[\frac{ms}{s}\right]}\right) \times 6{,}66\left[\frac{s}{s}\right]$$

d) T_D[s] =

$$\left(T_U[\,s\,] + \frac{T_A[ms\,]}{1000\left[\frac{ms}{s}\right]}\right) \times 0{,}6$$

2.8 Establishing parameters by experiment

Procedure

As an alternative to calculating the parameters you can establish the control parameters by means of targeted experimentation:

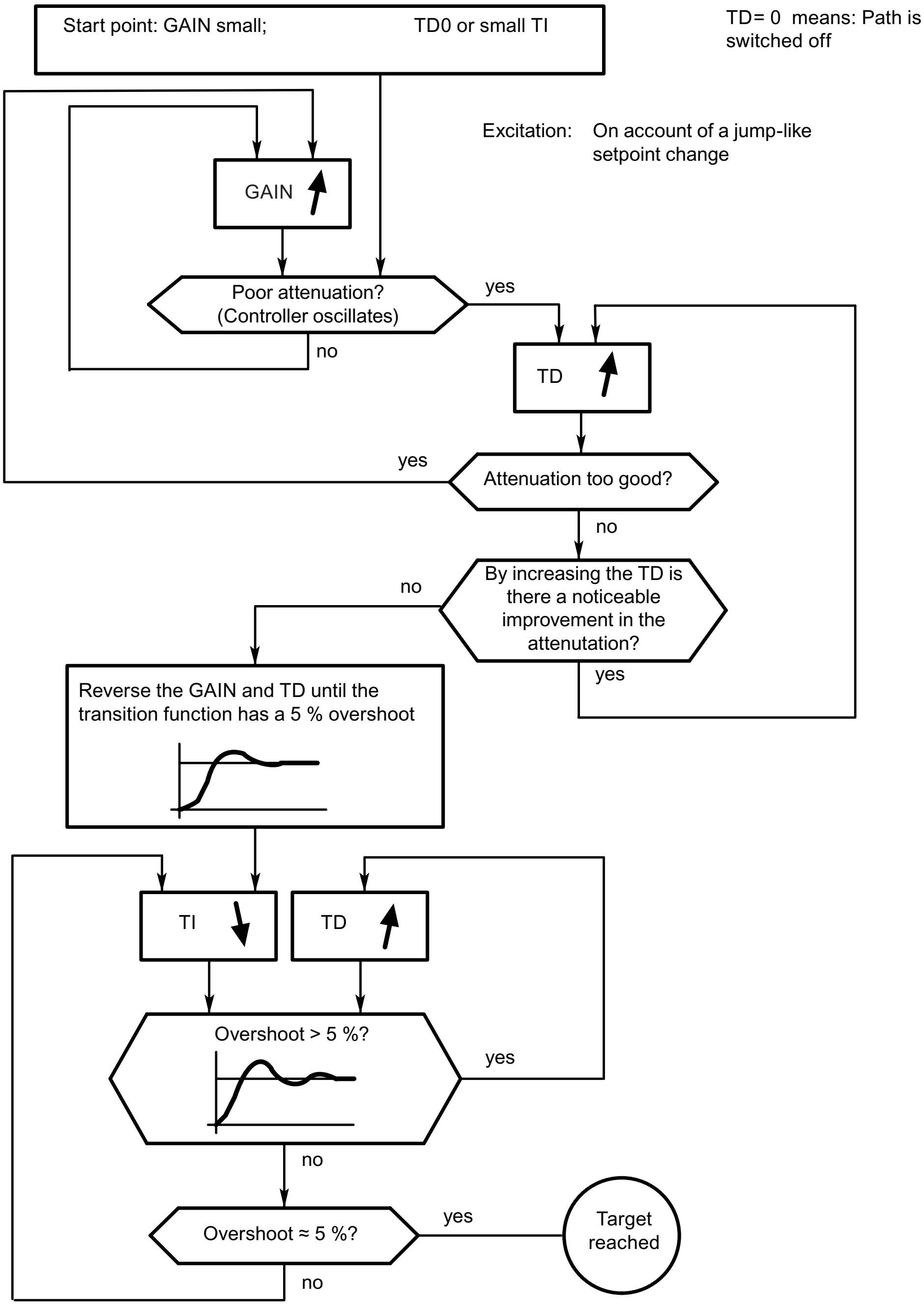


Figure 2-12 Setting the controller by means of targeted experimentation

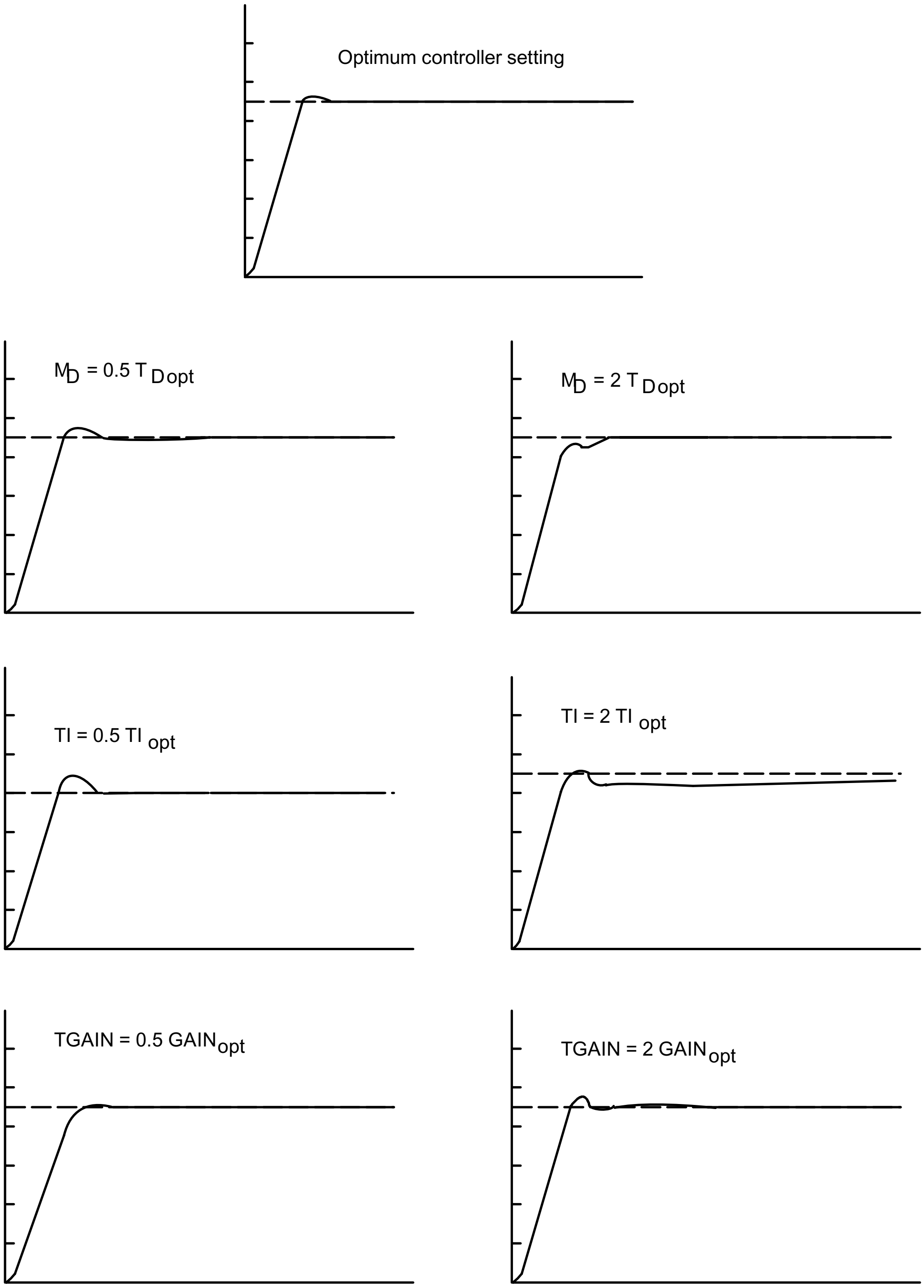


Figure 2-13 Effects on the optimum controller setting when changing the controller parameters

How Does the FM 355 Control? 3

3.1 Basic Structure of the FM 355

Introduction

This section uses block diagrams to explain the basic structure and the interconnection possibilities of the FM 355.

Basic Structure of the FM 355

FM 355 C and FM 355 S have a similar basic structure. It consists of the following function blocks:

- Inputs of the FM 355
  - 4 analog inputs with analog value conditioning
  - 1 reference junction input for compensating thermocouples
  - 8 digital inputs
- Controller
  - 4 controller channels independent of each other, each subdivided into the units Negative deviation calculation, Control algorithm and Controller output
- Outputs of the FM 355
  - 4 analog outputs (only FM 355 C)
  - 8 digital outputs (only FM 355 S)

Block Diagram of the FM 355 C

The following figure shows the block diagram of the FM 355 C (continuous-action controller) and the interconnection possibilities under the individual function blocks.

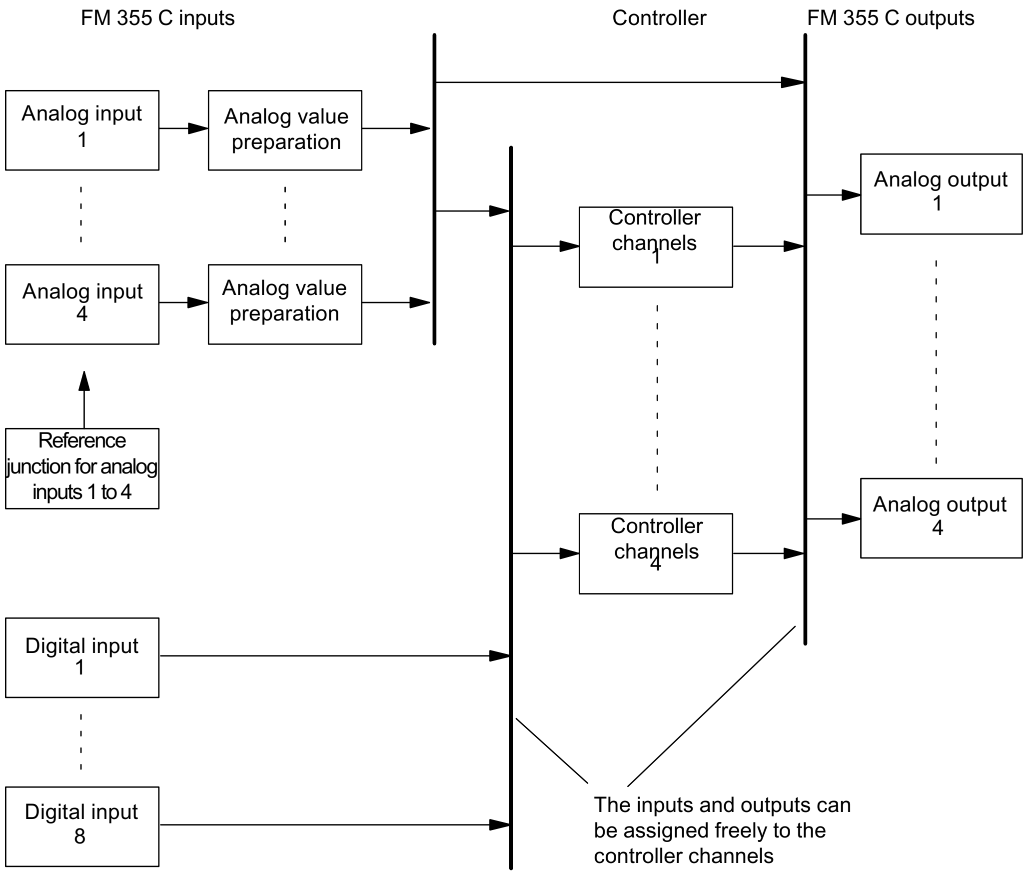


Figure 3-1 Block diagram of the FM 355 C (continuous-action controller)

Interconnection Possibilities of the FM 355 C

The function blocks of the FM 355 C do not have a fixed assignment to each other, so that they can be interconnected by configuring parameters.

Each analog input has its own analog value conditioning (filtering, linearization, scaling).

Up to 4 analog inputs and up to 3 digital inputs can be assigned to each controller channel. Each controller channel can be interconnected with the conditioned analog values, the digital inputs or also the output of another controller channel.

Each analog output can be interconnected with a controller output or with an analog value conditioning. The interconnection possibility with an analog value conditioning can, for example, be used to convert a non-linear temperature value into a linear output signal.

Block Diagram of the FM 355 S

The following figure shows the block diagram of the FM 355 S (step controller) and the interconnection possibilities under the individual function blocks.

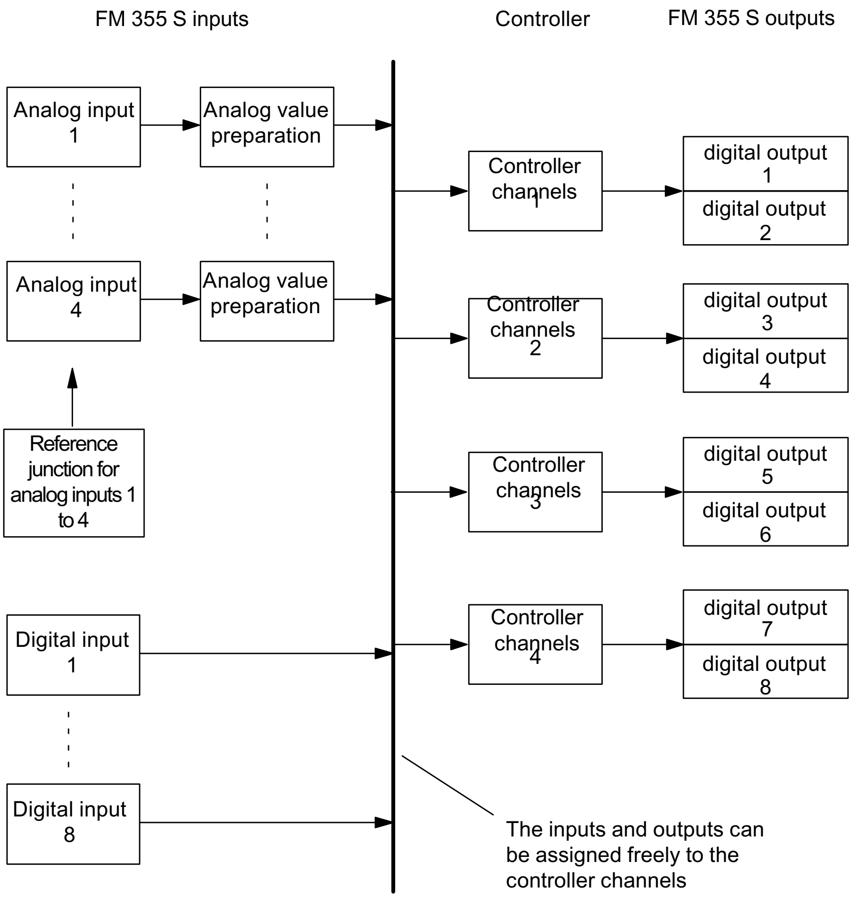


Figure 3-2 Block diagram of the FM 355 S (step controller)

Interconnection Possibilities of the FM 355 S

The function blocks of the FM 355 S do not have a fixed assignment to each other, so that they can be interconnected by configuring parameters.

Each analog input has its own analog value conditioning (filtering, linearization, scaling).

Up to 4 analog inputs and up to 5 digital inputs can be assigned to each controller channel Each controller channel can be interconnected with the conditioned analog values, the digital inputs or also the output of another controller channel.

Two digital outputs each have a fixed assignment to the 4 controller channels.

3.2 Basic Parameters

Introduction

The FM 355 has basic parameters that influence the interrupts and the reaction on CPU-STOP.

Basic Parameters

The basic parameters can be set under **HW Config** in the "Basic parameters" mask. The following settings are possible:

- Interrupt generation
  - Yes
  - No
- Interrupt selection
  - None
  - Diagnostics interrupt
- Reaction to CPU Stop
  - Continue

3.3 FM 355 inputs

Controller module inputs

Different types of sensor can be connected to the analog inputs. The input signals of the sensors are then conditioned in accordance with the requirements.

With the aid of the digital inputs, the module can be interconnected to different operating modes.

C controllers and S controllers have the same structure in the case of analog and digital inputs.

3.3.1 Analog inputs

Function blocks of an analog input

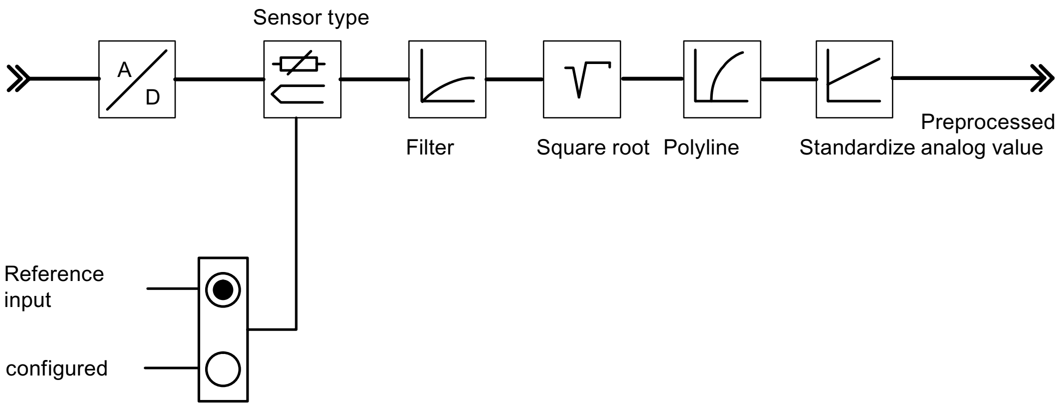


Figure 3-3 Analog value conditioning

Adapting to sensors

The analog inputs can be configured for adaptation to different sensors. The following settings are possible:

- Analog input is not being processed (e.g. unused input)
- Power sensors 0 mA to 20 mA
- Power sensors 4 mA to 20 mA
- Voltage sensors 0 V to 10 V
- Pt 100, –200 ... 850 °C
- Pt 100, –200 ... 556 °C (double resolution)
- Pt 100, –200 ... 130 °C (quadruple resolution)
- Thermocouple elements type B, J, K, R and S (analog input set to ±80 mV)
- Free thermocouple element (analog input set to ±80 mV)

You configure the analog inputs in the "analog input" screen.

Adapting to line frequency

To suppress interference when measuring analog signals, the input signal processing is adapted to the line frequency. The following settings are possible:

- 50 Hz operation
- 60 Hz operation

This configuration is carried out in the parameterization interface (button: **Module parameters**).

Toggling between Celsius / Fahrenheit

Temperatures can be measured in either °C or °F.

This configuration is carried out in the parameterization interface (button: **Module parameters**).

Reference junction

If you have set a thermocouple element as a sensor on an analog input, you can connect a Pt 100 at the reference junction input of the module in order to compensate for the reference junction temperature with thermocouple elements. Alternatively, a fixed reference junction temperature can be configured.

This configuration is carried out in the parameterization interface (button: **Module parameters**).

When using the reference junction input, the scanning time of each controller extends by the conversion time for the reference junction input.

Analog value conditioning

The analog value conditioning offers various configurable possibilities of preparing the input signals. The following table gives an overview of these parameters and the values that can be set.

Parameters	Values that can be set	Note
Resolution	• 12 bits • 14 bits	Conversion time 20 ms (50 Hz) Conversion time $16^2/_3$ ms (60 Hz) Conversion time 100 ms
Filters	• ON / OFF • Time constant in s	Filter - 1st arrangement the time response of which is established by the time constant
Square root	• ON / OFF	To linearize encoder signals where the actual value is given as a physical variable that is in quadratic connection with the measured process variable.
Standardization	• bottom • top	To convert the input signal into a different physical unit by means of linear interpolation between the start value (bottom) and the end value (top)
Polyline	• ON / OFF • 13 support points can be chosen in – mA with current input – mV with voltage input	To linearize encoder characteristic curves

Note

Standardization/polyline: The conversion of the unit mA or mV into a physical unit takes place either via the polyline or - if this is not switched on - via standardization. The polyline is used to linearize a free thermocouple element or for any other linearization.

3.3.2 Digital Inputs

Operating Modes

The digital inputs are used to switch between operating modes of the individual controller channels.

The direction of control action of the digital inputs can be configured. The following settings are possible for each of the eight digital inputs:

- High active
- Low active or open

This configuration is carried out in the parameter configuration interface (**Module parameters** button).

You can select the following operating modes:

- Switchover to specification of the manipulated value PID_FM FB
- Switchover to follow-up control mode (specification of the manipulated value via an analog input)
- Switchover to safety manipulated value

In the case of a step controller you can furthermore specify the following signals via digital inputs:

- Checkback: Actuating device at upper limit stop
- Checkback: Actuating device at lower limit stop

3.4 Controller

Controller structure

The controller of any channel of the module consists of the following blocks:

- Negative deviation generation
  - Condition of setpoint value and actual value
  - Signal selection for setpoint value, actual value, D-action input and disturbance variable
- Control algorithm
  - Temperature controller
  - PID-action controller with dead band
- Controller output
  - Manipulated value switchover
  - Manipulated value conditioning

The parameter configuration is carried out in the masks "Negative deviation calculation", "Control algorithm" and "Controller output".

The figure below provides an overview of the controller structure.

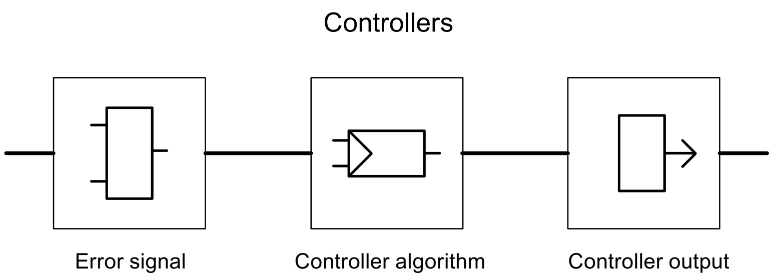


Figure 3-4 Controller structure

Controller Type

You can set different controller types for each controller channel of a C or S controller module

- Fixed setpoint or cascade controller
- Three-component controllers
- Ratio/blending controllers

The following operating modes can furthermore be selected at the step (S) controller:

- Pulse controller
- Step controller with position feedback
- Step controller without position feedback

Negative deviation generation

In the case of all controller types realized in the FM 355 C and FM 355 S, the negative deviation generation is based on the same basic structure.

An effective setpoint value and an effective actual value is formed from the setpoint value and actual value by corresponding conditioning. The negative deviation that is fed to the controller is formed by subtracting the effective setpoint value and effective actual value.

A signal selection can be carried out for the setpoint and actual values. This results in universal application possibilities for the controller module.

The structures of negative deviation generation differ depending on the selected controller type. The differences are shown in the following figures.

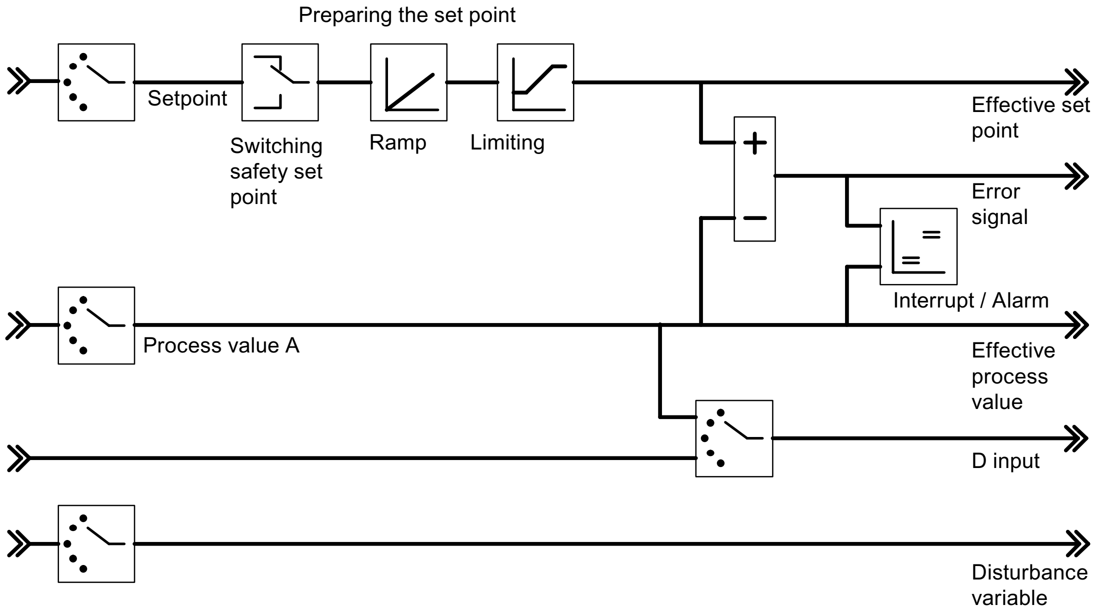


Figure 3-5 Negative Deviation Generation at Fixed Setpoint or Cascade Controller

The manipulated value of a master controller is selected at the setpoint value at the cascade controller. In the example from the figure below the manipulated value of Controller 1 is selected as the setpoint value at Controller 2.

If a secondary controller that is configured as a fixed setpoint controller is switched to manual operation (not closed-loop control operation), the master controller is also switched automatically to manual operation by the module and is held to the last manipulated value. As soon as the secondary controller returns to closed-loop control operation, the master controller also switches over to closed-loop control operation.

If the manipulated variable of a secondary controller enters the limiting function or if the setpoint value increase of a secondary controller is limited by the ramp function in the setpoint value branch, the I-action component of the master controller is blocked direction-specifically until the cause for the limitation has been eliminated in the secondary controller.

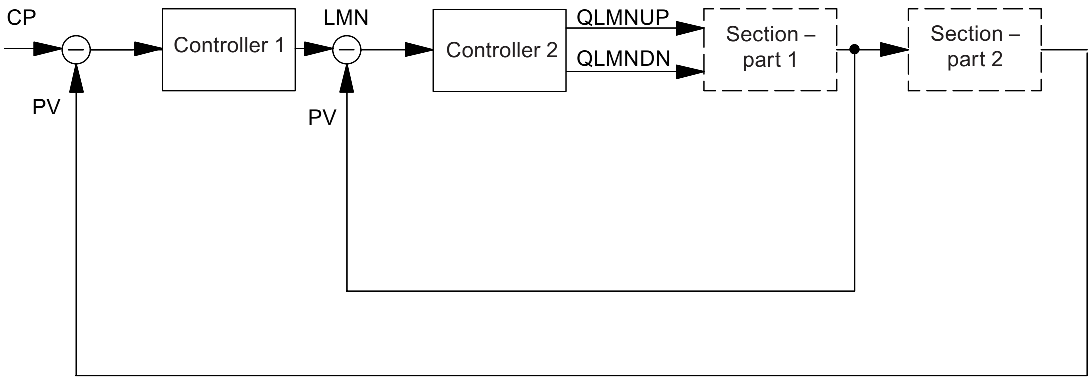


Figure 3-6 Two-loop cascade control

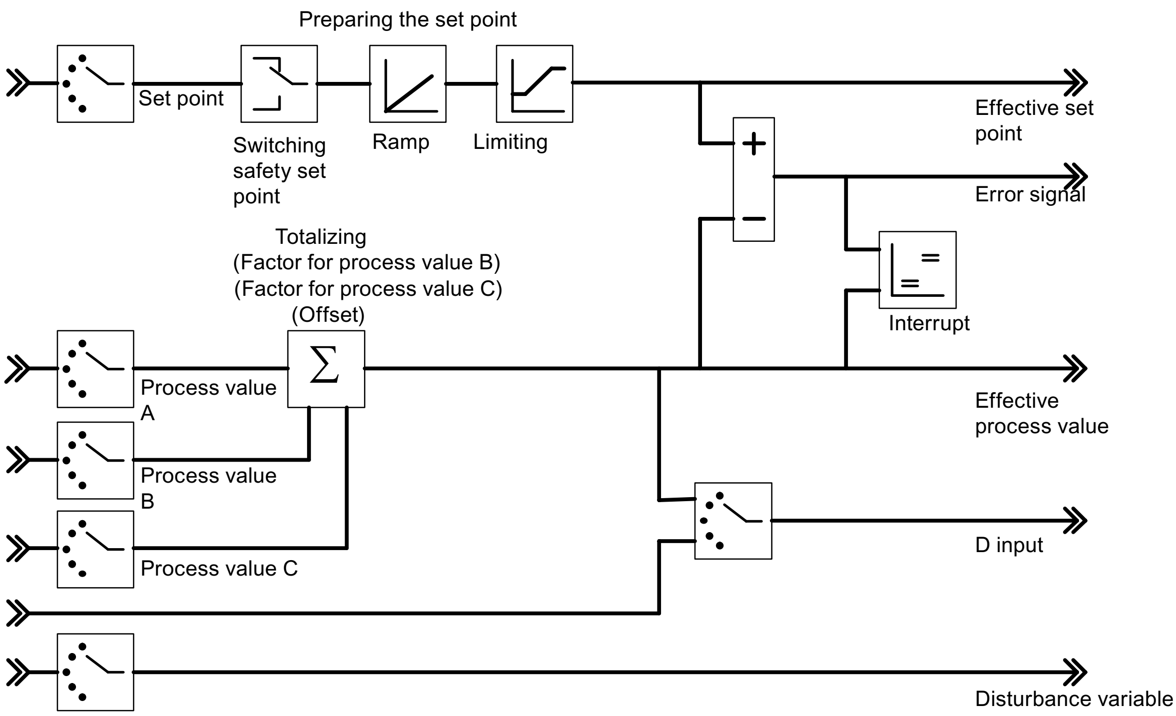


Figure 3-7 Negative deviation generation for three-component controllers

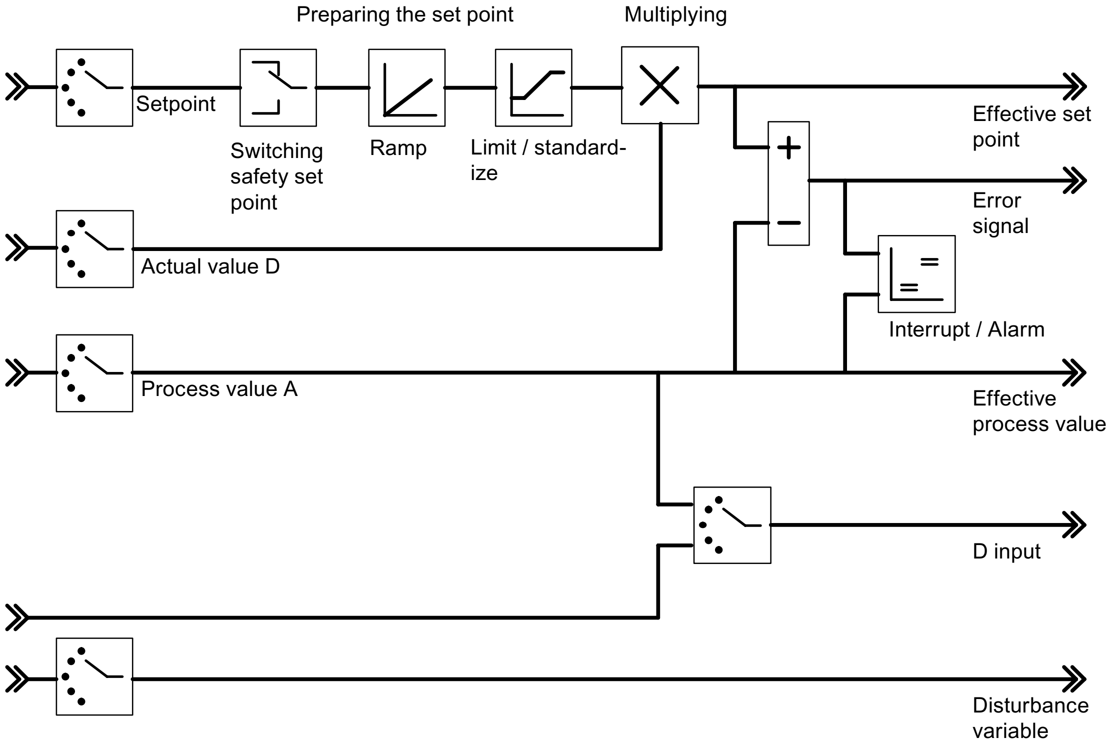


Figure 3-8 Negative deviation generation for ratio or composition controllers

The following figure shows a blending control for three components.

The total quantity controller is implemented as a three-component controller/pulse controller. The total quantity PV is calculated via its inputs "Actual value A", "Actual value B" and "Actual value C".

The secondary controllers are configured as ratio/blending controllers. The manipulated variable of the master controller is connected via the "Actual value D" input. The factor FAC1 to FAC3 is specified via the setpoint value input of the controller.

The manipulated variable LMN of the total quantity controller is specified in the range of values 0% to 100%. The secondary controller converts this variable at the Actual value input D into the value range of the Actual value A (the value range of the Actual value A consists of the "Upper" and "Lower" normalization values of the selected analog input).

If the manipulated variable of a secondary controller enters the limiting function or if the setpoint value increase of a secondary controller is limited by the ramp function in the setpoint value branch, the I-action component of the master controller is blocked direction-specifically until the cause for the limitation has been eliminated in the secondary controller.

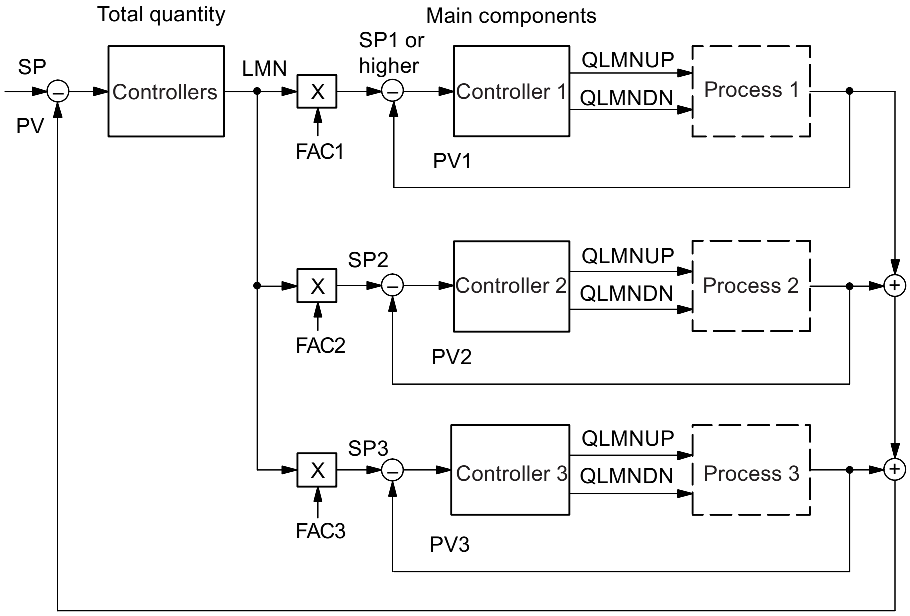


Figure 3-9 Mixed controllers for three components

The following figure shows a ratio control with two control loops.

Controller 1 is configured as a fixed setpoint or cascade controller.

Controller 2 is configured as a ratio/blending controller. The actual value of Controller 1 is selected as the Actual value D of Controller 2. The ratio factor FAC is specified via the setpoint value input of Controller 2. If a controller output is called as ratio factor FAC, then the setpoint will be converted (standardized) with the help of an upper and lower barrier from "0 .. 100%" to the value range "bottom barrier... top barrier" (standardized).

If the manipulated variable of a secondary controller enters the limiting function or if the setpoint value increase of a secondary controller is limited by the ramp function in the setpoint value branch, the I-action component of the master controller is blocked direction-specifically until the cause for the limitation has been eliminated in the secondary controller.

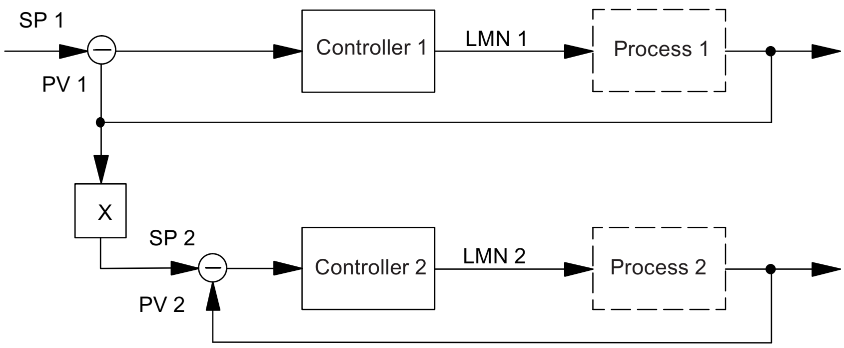


Figure 3-10 Ratio control with two control loops

Signal Selection for Setpoint Value, D-Action Input and Disturbance Variable

You can carry out a selection amongst various signal sources for the setpoint value, the actual values, the value of the D-action input (differential input) and the disturbance variable of each controller channel. The following table provides an overview of the signal selection possibilities.

Table 3-1 Signal selection for setpoint value, D-action input and disturbance variable

Affected values	Selectable signal source
Setpoint	• A value specified by the user program through the function block • The conditioned analog value of an analog input • The manipulated value of another controller channel (when controllers are cascaded)
Actual values A, B and C	• The conditioned analog value of an analog input (Actual values B and C can also be deactivated)
Actual value D	• Zero (Actual value D can also be deactivated)
Value for D-action input (only relevant for PD- or PID-action controllers)	• The negative deviation after the dead band of the own controller channel • The conditioned analog value of an analog input • The negated effective actual value of the own controller channel
Interference	• The conditioned analog value of an analog input (the value zero can also be specified for the disturbance variable)

Setpoint Value Conditioning

Conditioning of the setpoint value to an effective setpoint value can be influenced by the following parameter configuration possibilities:

- Switching the safety setpoint value

  The following can be set here:

  – A safety setpoint value

  – The reaction of the controller module at a CPU failure

  – The reaction of the controller module at a startup

    The alternatives for the reaction of the controller module are:

    Setpoint value = Last setpoint value

    Setpoint value = Safety setpoint value

- Ramp

  You can limit the speed of change of the setpoint value by selecting a ramp-up time from the engineering starting value to end value.

- Limiting/Normalizing

  The setpoint value is limited to a specifiable lower and upper limit when the setpoint value is specified by the function block or when the setpoint value is a conditioned analog value of an analog input.

If, in the case of ratio controllers, a controller output is chosen as the set value, then this value acts as a factor for the multiplication of the actual value D. The set value that is given at the input in %, is in this case converted (standardized) with the aid of the bottom and top barriers.

If the manipulated value of another controller is used as the setpoint value at a fixed setpoint or cascade controller (for example at the cascade control function, this is normalized to an engineering value by means of the normalizing constant of the selected actual value channel.

- Multiplication

  At the "ratio controller" controller type, Actual value A is used as the controlled variable, Actual value D as the ratio variable. The setpoint value input serves as the ratio factor. It is conditioned as the effective setpoint value by multiplication with Actual value D and addition of an offset that can be set. If Actual value D is deactivated, only the offset is added to the setpoint value.

Actual Value Conditioning

In the case of the "fixed-setpoint or cascade controllers" and "ratio controllers" control structures the effective actual value is identical with Actual value A.

In the case of the "Three-component controllers" control structure the effective actual value is formed by totaling the three actual values A, B and C and by adding an offset that can be set. Actual values B and C can be evaluated additionally through factors.

Interrupt

A limit monitoring function is implemented in the controller module. This allows

- either the negative deviation or
- the effective actual value

to be monitored to an upper and lower warning limit and an upper and lower interrupt limit. In addition you can set a hysteresis for these limits (refer to the following figure).

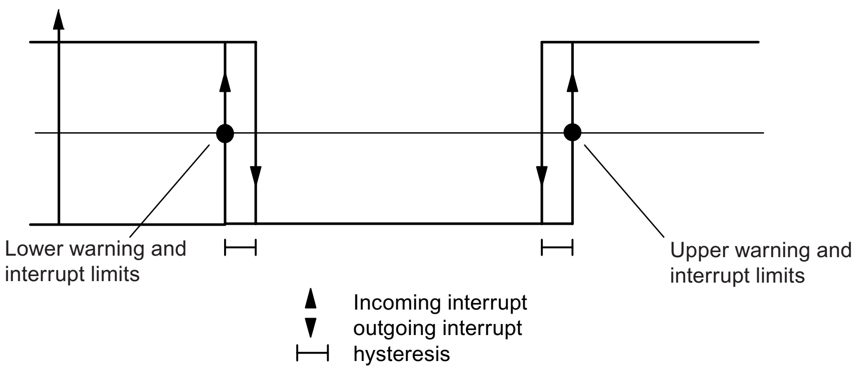


Figure 3-11 Hysteresis for warning and interrupt limits

Control Algorithm

At the control algorithm you can select between the following operating modes:

- Temperature controller (self-tuning fuzzy controller)
- PID-action controller

Continuous-action controllers and step controllers have the same control algorithm structure (refer to the following figure).

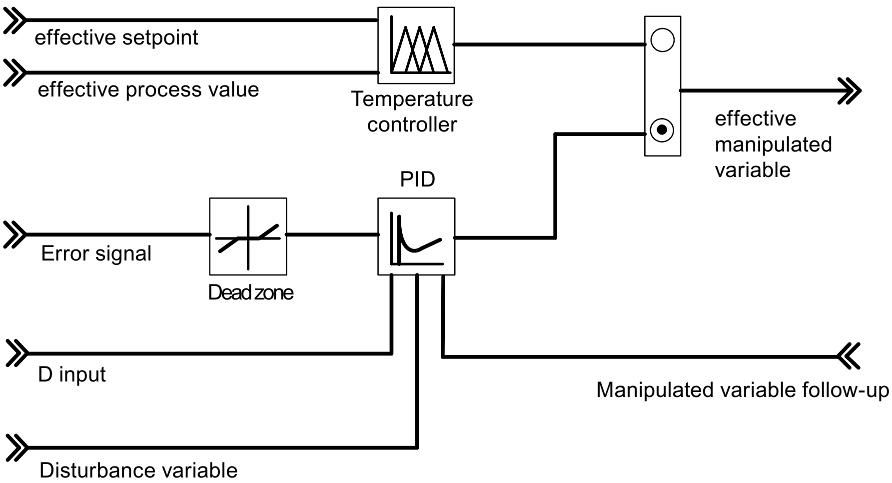


Figure 3-12 Block diagram of the control algorithm

Temperature Controller

The temperature controller is a self-tuning fuzzy controller that operates with self-determined control parameters after an identification of the controlled system.

The following settings are possible at the temperature controller:

- Cooling controller
- Heating controller
- Aggressivity

  You can influence the speed of the transient behavior by using the Aggressivity parameter.

Possible values for the aggressivity	
$-1 \leq$ Aggressivity < 0	Slower transient response than determined via identification
Aggressivity = 0	Transient response as determined via identification
0 < Aggressivity ≤ 1	Faster transient response than determined via identification

You will find a detailed description of the temperature controller in the *Temperature regulator FM 355* manual.

Control Algorithm and Controller Structure

Within the cycle of the configured sampling time the manipulated variable of the continuous controller is calculated from the negative deviation in the PID position algorithm. The controller is designed as a purely parallel structure (refer to figure below). The proportional, integral or derivative actions can each be deactivated individually. At the integral- and differential-action components this is done by setting the respective parameter TI or TD to zero.

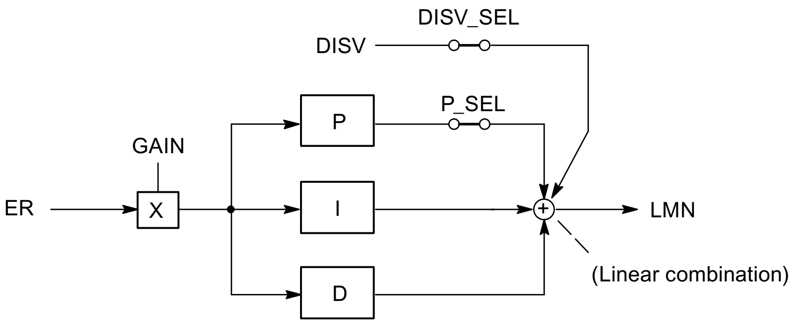


Figure 3-13 Control algorithm of the FM 355 (parallel structure)

Disturbance variable compensation

A disturbance variable **DISV** can additionally be fed forward to the output signal of the controller. Activation and deactivation is carried out in the "Negative deviation" window of the configuration tool via the "Signal selection disturbance variable controller" switch.

P / D part in the feedback

In a parallel structure the negative deviation is used as the input signal at every action component of the control algorithm. In this structure setpoint steps act directly on the controller. The manipulated variable is influenced directly via the P- and D-action components through setpoint steps.

However, a different structure of the controller, in which the formation of the P-action and D-action components is moved to the feedback, guarantees a smooth course of the manipulated variable at step changes in the reference variable (see following figure).

In this structure the I-action component processes the negative deviation as the input signal. Only the **negative** controlled variable (factor = - 1) is fed forward to the P-action and D-action components. In the D-action component the changeover to the feedback is carried out in the "Negative deviation" window via the "D-action input controller" switch by selecting the negated effective actual value as the input signal. The input variable of the D-action component can also be selected via the D_EL_SEL parameter of the PID_FM function block.

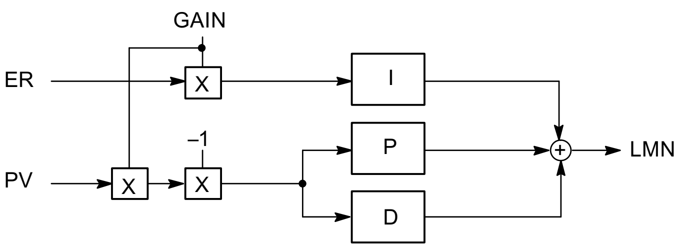


Figure 3-14 Control algorithm with P- and D-action component in the feedback path

Reversing of the Controller Action

Reversal means, changing the controller from the assignment

- Rising controlled variable = **Rising** manipulated variable to
- Rising controlled variable = **Falling** manipulated variable

is achieved by setting a negative proportional-action gain at the GAIN parameter. The sign of this parameter value is defined by the direction of control action of the controller.

P-Action Control

The I-action and the D-action components are deactivated at the P-action controller. This means that the manipulated value also equals 0 when the Negative deviation ER = 0. If an operating point is to be ≠ 0, i.e. if a numerical value is to be set for the manipulated variable at negative deviation zero, this can be done via the operating point:

- Operating point automatic: The operating point is set to the current (manual) manipulated variable at the manual-automatic changeover of the controller.
- Operating point not automatic: You can configure the operating point parameter.

  Example: Operating point OP = 5% results in a manipulated variable of 5% at Negative deviation ER = 0.

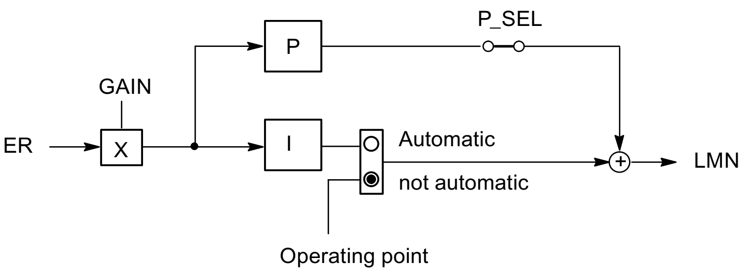


Figure 3-15 P-action controller with operating point setting via I-action element

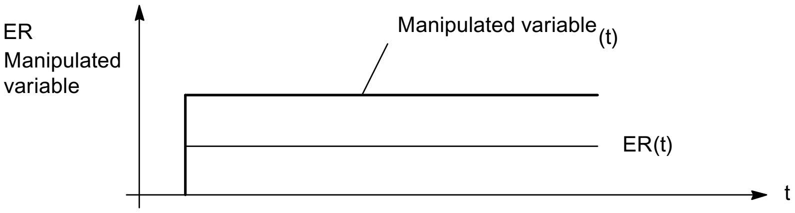


Figure 3-16 Step response of the P-action controller

PI Control

The D-action component is deactivated at the PI-action controller. A PI -action controller adjusts the output variable via the I-action component until the Negative deviation ER = 0. However, this only applies if the output variable does not exceed the limits of the operating range. If the manipulated variable limits are exceeded, the I-action component retains the value reached at the limit (anti reset wind-up).

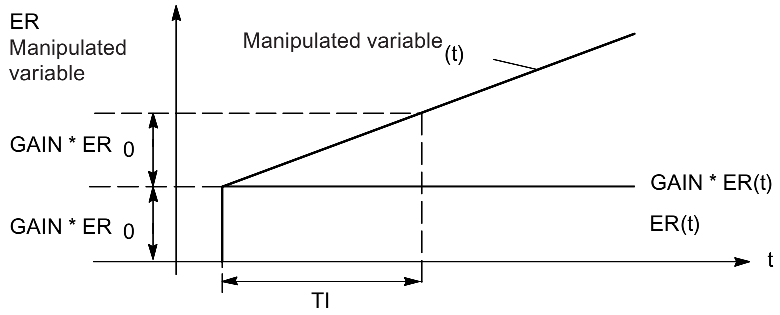


Figure 3-17 Step response of the PI-action controller

Smooth Changeover between Manual and Automatic Mode

In order to change over smoothly from manual mode to automatic mode of the PI-/PID-action controller, the integrator is corrected in manual mode so that the manipulated variable does not carry out step changes through the P- and D-action components during a changeover from manual to automatic mode. An existing negative deviation is only corrected slowly via the I-action component. If no smooth changeover from manual to automatic mode is selected, the manipulated variable makes a step change, that corresponds to the current negative deviation, starting from the current manual value during a changeover from manual to automatic mode. An existing negative deviation is thus corrected rapidly.

I Control

You can deactivate the P-action component in order to implement a pure I control. This is also possible by using the P_SEL parameter of the PID_FM function block.

PD Control

The I-action component is deactivated at the PD-action controller. This means that the output signal also equals 0 when the Negative deviation ER = 0. If an operating point is to be ≠ 0, i.e. if a numerical value is to be set for the manipulated variable at negative deviation zero, this can be done via the operating point:

- Operating point automatic: The operating point is set to the current (manual) manipulated variable at the manual-automatic changeover of the controller.
- Operating point not automatic: You can configure the operating point parameter.

The PD-action controller maps the input variable ER(t) proportionally to the output signal and adds the D-action component formed through differentiation of ER(t) that is calculated with double precision in accordance with the trapezoid rule (Padé approximant). The time response is determined by the differentiation time constant (differential-action time) TD.

For smoothing and suppressing disturbance signals, a delay of the 1st arrangement (time constant that can be set: TM_LAG) is integrated in the algorithm to form the D part. Usually a small value for TM_LAG is sufficient in order to achieve the desired success.

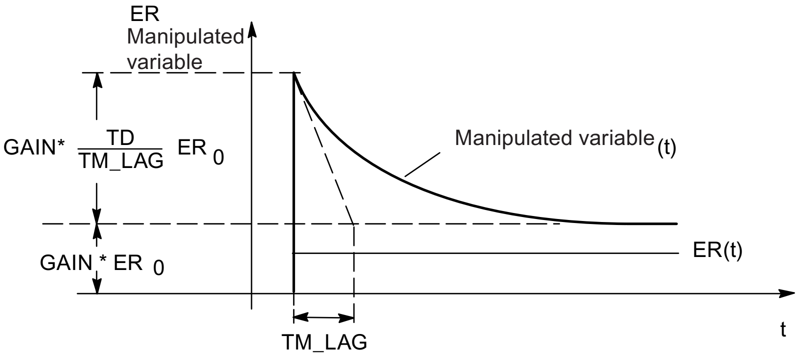


Figure 3-18 Step response of the PD-action controller

PID-action Control

The P-action, I-action and D-action components are activated at the PID-action controller. A PID-action controller adjusts the output variable via the I-action component until the Negative deviation ER = 0. However, this only applies if the output variable does not exceed the limits of the operating range. If the manipulated variable limits are exceeded, the I-action component retains the value reached at the limit (anti reset wind-up).

The PID-action controller maps the input variable ER(t) proportionally to the output signal and adds the components formed through differentiation and integration of ER(t) that are calculated with double precision in accordance with the trapezoid rule (Padé approximant). The time response is determined by the differentiation time constant (differential-action time) TD and the integration time constant (reset time) TI.

For smoothing and suppressing disturbance signals, a delay of the 1st arrangement (time constant that can be set: TM_LAG) is integrated in the algorithm to form the D part. Usually a small value for TM_LAG is sufficient in order to achieve the desired success

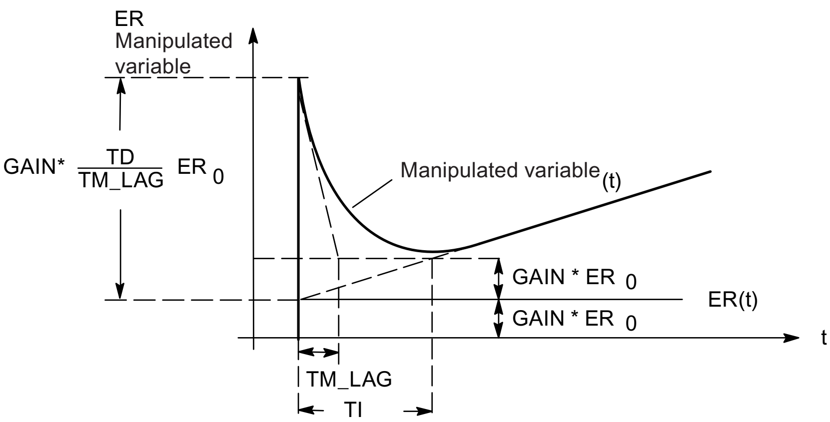


Figure 3-19 Step response of the PID-action controller

Use and Configuration of the PID Controller

A major practical problem is the configuration of the PI-/PID-action controller parameters, i.e. finding the "correct" setting values for the controller parameters. The quality of this configuration is of decisive importance to ensure that the PID control functions in accordance with the required task and requires either a high degree of practical experience, special knowledge or a large amount of time.

The Optimize PID-action controller function contained in the Configuration tool is used for initial setting of the controller parameters through adaptive commissioning. This means that the process model is determined after a system identification and then the most favorable (optimal) setting values calculated for the controller parameters. This procedure, which is automatic to a great extent, means that the user does not have to tediously "trim" the installed PID-action controller online manually.

Dead Band

A dead band is positioned upstream of the PID-action controller. In a steady controller state the dead band suppresses the noise in the negative deviation signal, which can arise through superimposition of a higher-frequency interference signal over the controlled or reference variable, thus preventing undesired oscillation of the controller output.

The dead band width can be adjusted. If the negative deviation lies within the set dead band width, the value 0 (Negative deviation = 0) is output at the dead band output. Only when the input variable leaves the sensitivity range, does the output change by the same values at the input variable (see the figure below).

This results in a transferred signal being corrupted, also outside the dead band. However, this is accepted in order to avoid step changes at the limits of the dead band. The corruption corresponds to the value of the dead band width and can therefore be controlled easily.

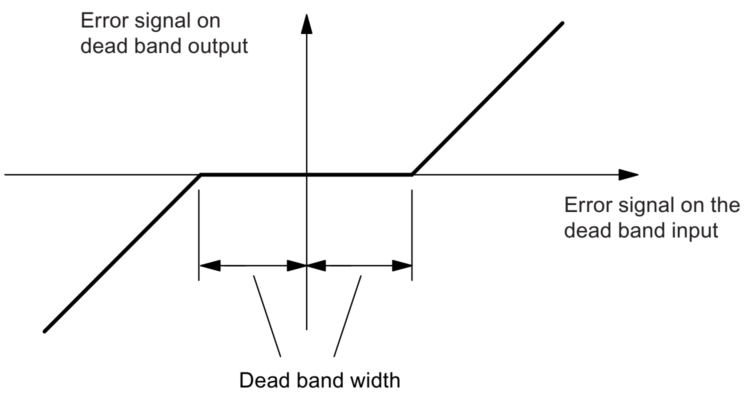


Figure 3-20 Dead band

Controller Output

The controller output block of the control unit has a different structure at the continuous-action controller and at the three operating modes of the step controller.

Various interconnection possibilities are implemented at the controller output for the manipulated value, the tracking input and the safety manipulated value (manipulated value switchover).

To avoid the manipulated value adopting illegal values for the process, a limit is specified.

The split range function generates from the manipulated value as an input signal two differently standardized output signals - manipulated value A and manipulated value B. This way, for example, two values can be controlled with one manipulated value.

The manipulated value correction prevents a step change at the manipulated value during the changeover from manual to automatic mode.

The manipulated value remains unchanged during the changeover from manual to automatic mode. Manipulated value correction is not active when a pure P-action controller with fixed operating point is implemented ("automatic" is not activated in the PID-action controller mask).

Controller Output of the Continuous-Action Controller

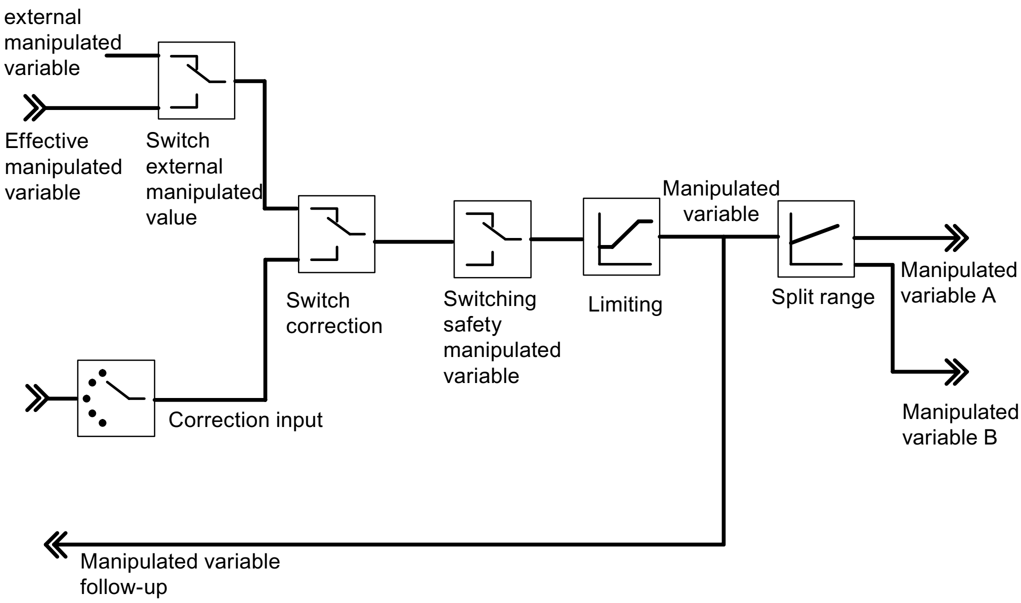


Figure 3-21 Controller output of the continuous-action controller

Split-Range Function

The split-range function is used to control two control valves with one manipulated variable. The split-range function generates the two output signals, Manipulated value A and Manipulated value B, from the manipulated value LMN as the input signal.

The following figure shows the effect of the parameters for the output manipulated value A.

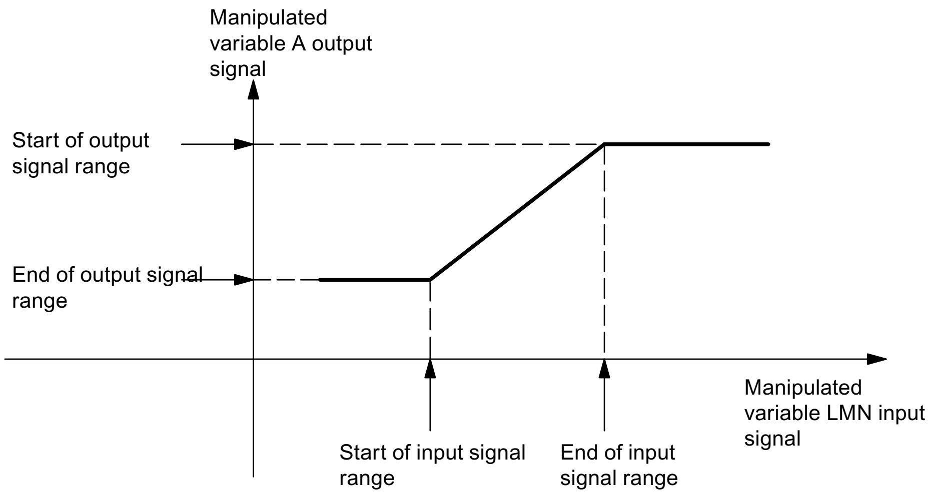


Figure 3-22 Split-range function manipulated value A

The following figure shows the effect of the parameters for the output manipulated value B.

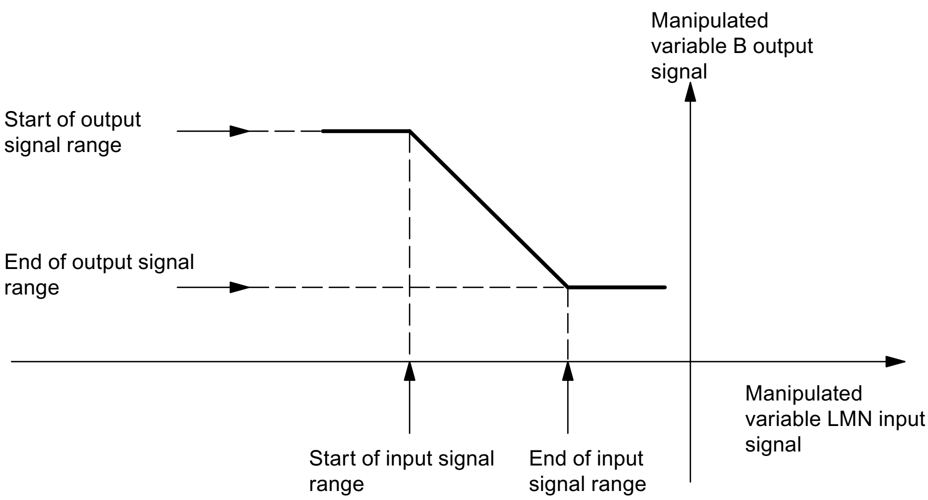


Figure 3-23 Split-range function manipulated value B

The start of range of the input signal must be smaller than the end of range of the input signal.

Analog Output

And the analog output you can select the signal that is to be output for each channel. This is usually the Manipulated value A of a controller. However, you can also select the Manipulated value B of a controller or also an analog input value. The latter can be used for the linearization of an analog value. This allows, for example, the signal supplied by a thermocouple to be linearized and converted to 0 V to 10 V.

Controller Output of the Pulse Controller

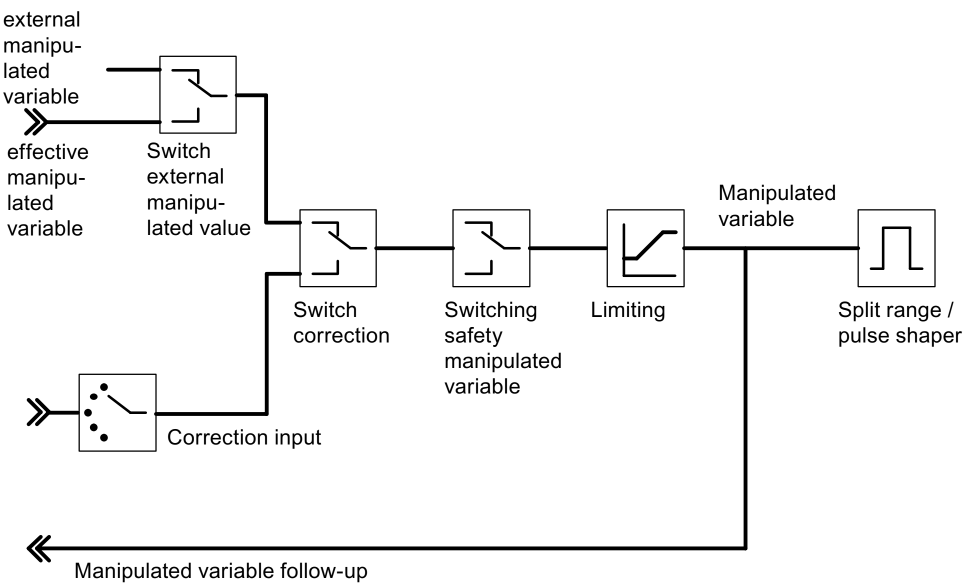


Figure 3-24 Controller output of the step controller (pulse controller operating mode)

Split-Range Function/Pulse Generator

The split-range function is the preparation of the analog signal for conversion to a binary signal.

In the case of a two-step controller (for example, a heating controller) only manipulated variable A is relevant. The conversion of the manipulated value to the manipulated value A is shown in the figure below "Split-range function two-step controller". The conversion to a binary output signal is carried out so that the ratio of pulse length to period duration corresponds to the manipulated value A at the assigned digital output.

For example, a manipulated value A of 40% at a period duration of 60 seconds results in a pulse length of 24 seconds and a pause duration of 36 seconds.

The classification of the digital outputs to the controller channels can be found in the table in the section "FM 355 outputs".

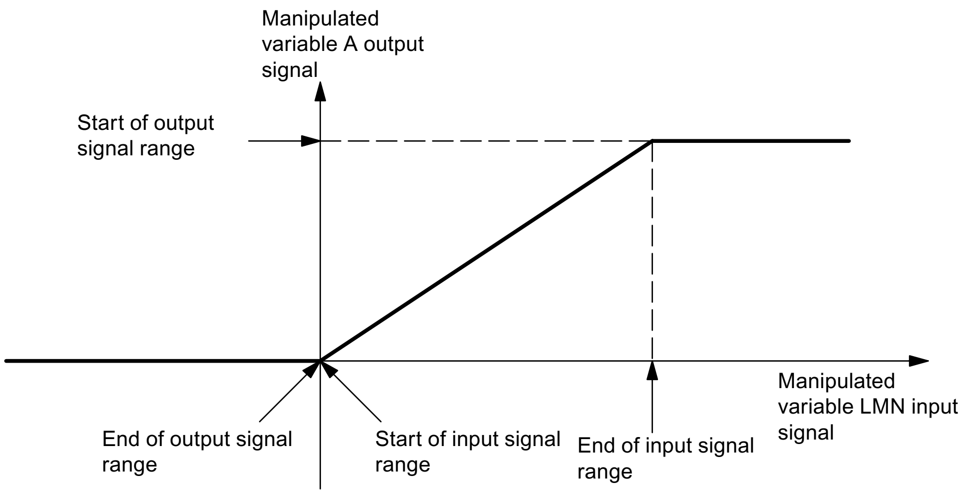


Figure 3-25 Split-range function two-step controllers

In the case of a three-point controller (for example, as a heating and cooling controller) the statements above apply for the manipulated value A. The second signal for controlling the cooling is formed via the manipulated value B. The conversion of the manipulated value to the manipulated values A and B is shown in the figure below. The conversion to a binary output signal is carried out so that the ratio of pulse length to period duration corresponds to the manipulated values A and B at the assigned digital outputs.

The classification of the digital outputs to the controller channels can be found in the table "Functions of the controller output and setting possibilities".

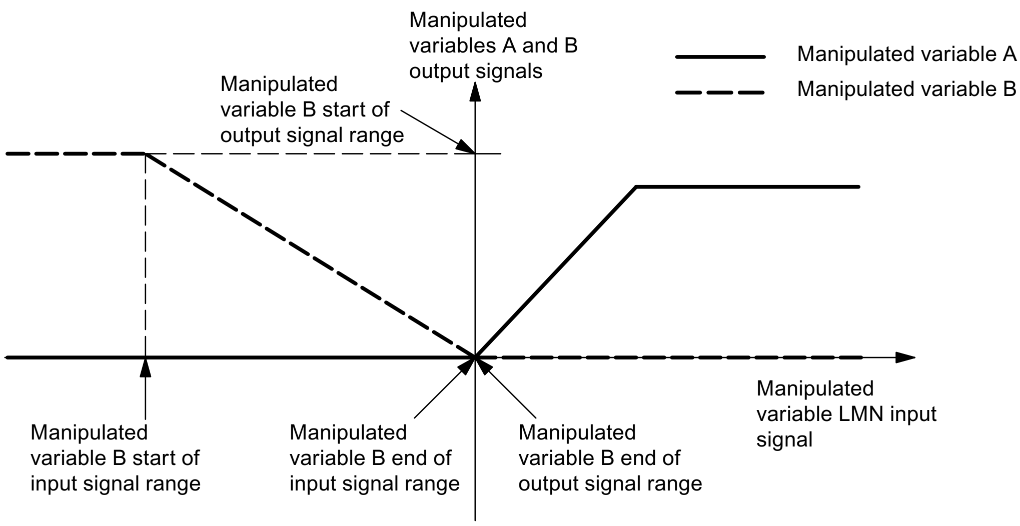


Figure 3-26 Split-range function three-step controller

Controller Output of the Step Controller

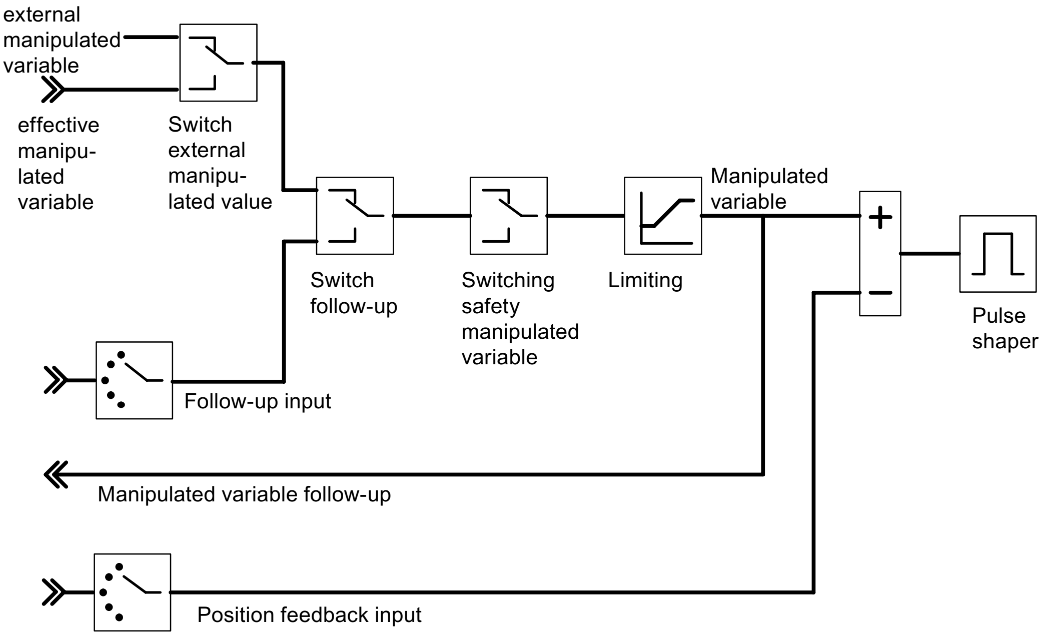


Figure 3-27 Controller output of the step controller (step controller operating mode with position feedback)

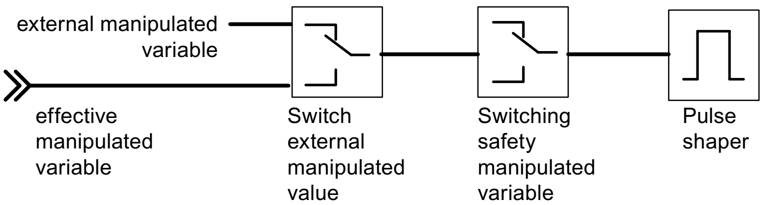


Figure 3-28 Controller output of the step controller (step controller operating mode without position feedback)

At a step controller without analog position feedback the external manipulated value and the safety manipulated value act as follows:

If a value between 40.0% and 60.0% is specified, no binary output is set and the actuating device remains unchanged.

If a value > 60.0% is specified, "Actuating signal high" is output until the checkback "Actuating device at upper limit" is triggered.

If a value < 40.0% is specified, "Actuating signal low" is output until the checkback "Actuating device at lower limit" is triggered.

Functions and parameters of the controller output

The following table lists the functions of the controller output and the setting possibilities.

Table 3-2 Functions of the controller output and setting possibilities

Functions of the controller output	Adjustable parameters
Switching of external manipulated value	The changeover between an external manipulated value and the effective manipulated value is carried out alternatively by • a binary value from the function block • a signal that results from the ORing of a binary value from the function block and a digital input
Tracking input	The following alternative settings are available: • The tracking input has the value zero • The tracking input is the conditioned analog value of an analog input
Position feedback input (only step controller)	The following alternative settings are available: • The position feedback input has the value zero • The position feedback input is the conditioned analog value of an analog input
Switching to tracking	The changeover between the manipulated value and the tracking input is carried out alternatively • A binary value from the function block • A signal that results from the ORing of a binary value from the function block and a digital input
Switching to safety manipulated value	• Determination of the safety manipulated value • Alternative reaction of the FM 355 during start up: – The FM 355 goes into closed-loop control operation – The safety manipulated value is output as the manipulated value • The changeover to the safety manipulated value is carried alternatively by – A binary value from the function block – A signal that results from the ORing of a binary value from the function block and a digital input • Reaction at a measuring transducer fault of Actual value A: – The operating mode of the controller remains unchanged at the setting "Closed-loop control operation" – If the setting is "Manipulated value = Safety manipulated value", the system changes over to the safety manipulated value • Reaction at a measuring transducer fault of an analog input: – The operating mode of the controller remains unchanged at the setting "Closed-loop control operation" – If the setting is "Manipulated value = Safety manipulated value", the system changes over to the safety manipulated value
Manipulated value limit	Upper and lower limit (cannot be deactivated)
Generation of the split-range manipulated values	• On/off (only continuous-action controllers) • Starting and end value of input signal • Starting and end value of output signal
Pulse generator (only step controller)	• Motor actuating time • Minimum pulse time • Minimum break time

See also

Parameter optimization with temperature controllers (Page 3-41)
Introduction (Page 7-2)

3.5 Outputs of the FM 355

Analog Outputs of the FM 355 C

You can carry out the following specifications through parameter configuration for each analog output of the FM 355 C:

- Signal selection
- Signal type

The output parameters are configured in the "Signal selection analog output" and "Signal type analog output" masks.

Signal Selection at the Analog Outputs

With the signal selection you can specify which signal value is to be output at the respective analog output.

The following signal values can be assigned:

- The value zero
- The conditioned analog value of the four analog inputs
- Manipulated value A of one of the four controller channels
- Manipulated value B of one of the four controller channels

Signal Type at the Analog Outputs

You can determine the signal type for each analog output.

The following signal types can be assigned:

- Current output 0 mA to 20 mA
- Current output 4 mA to 20 mA
- Voltage output 0 V to 10 V
- Voltage output -10 V to 10 V

Digital Outputs of the FM 355 S

The digital outputs of the FM 355 S are used to control integrating or non-integrating actuators.

The assignment of the digital outputs to the controller channels and their meaning are shown in the following table:

Table 3-3 Assignment and meaning of the digital outputs

Controller channel	Digital outputs assigned to the controller channel	Meaning of the digital outputs at the step controller	Assignment of the digital outputs at the pulse controller
1	1	Open	Manipulated value A
	2	Close	Manipulated value B
2	3	Open	Manipulated value A
	4	Close	Manipulated value B
3	5	Open	Manipulated value A
	6	Close	Manipulated value B
4	7	Open	Manipulated value A
	8	Close	Manipulated value B
Open: Opening the actuating device Close: Closing the actuating device			

3.6 Functional mechanisms and data storage in the FM 355

Overview

This chapter covers important functional mechanisms and the principle of data storage in the controller module.

The parameter configuration interface of the programming device/PC can be used to carry out the following actions on the controller module

- parameter configuration,
- optimizing,
- operator control and monitoring.

The PID_FM function block (FB) that belongs to the scope of delivery can be used to connect the module with a user program.

Parameter settings

The FM 355 is configured by means of a parameter configuration interface on the programming device (refer to the chapter "Wiring the FM 355"). All the parameter configuration data are stored in a SDB on the programming device.

Note

Only in the STOP state of the CPU can you download the SDB configuration data into the CPU and into the FM 355 via an online connection between the programming device and the CPU. This is only possible via the HW Config. In doing so, the parameter configuration interface must be closed.

The FM 355 is supplied again with the parameters from the SDB in the CPU during every start-up and during the transition of the CPU from STOP to RUN.

Downloading the Parameters Directly into the FM 355

It is also possible to download the parameters directly into the FM 355 via the parameter configuration interface so that you do not have to close the parameter configuration interface and set the CPU to the STOP state several times consecutively while the parameter configuration is being tested during commissioning.

Please note that the parameters loaded by this method are overwritten by the parameters from the SDB of the CPU when the CPU is started up and at a STOP-RUN transition of the CPU. An FB call can also overwrite the parameters loaded directly from the parameter configuration interface.

Downloading directly into the FM 355 is therefore only advisable when testing the parameter configuration during commissioning.

If you change the parameters via the parameter configuration interface and then download them directly into the FM 355, step changes can occur in the manipulated value course. In order to achieve a controlled manipulated value course we recommend the following procedure:

1. Switch to manual operation (for example via the loop display).
2. Change the parameters.
3. Download them directly into the FM 355
4. Switch to automatic operation (for example via the loop display).

Data Flow during Parameter Configuration via the Parameter Configuration Interface

The following figure shows the path of the parameter configuration data from the parameter configuration interface to the FM 355.

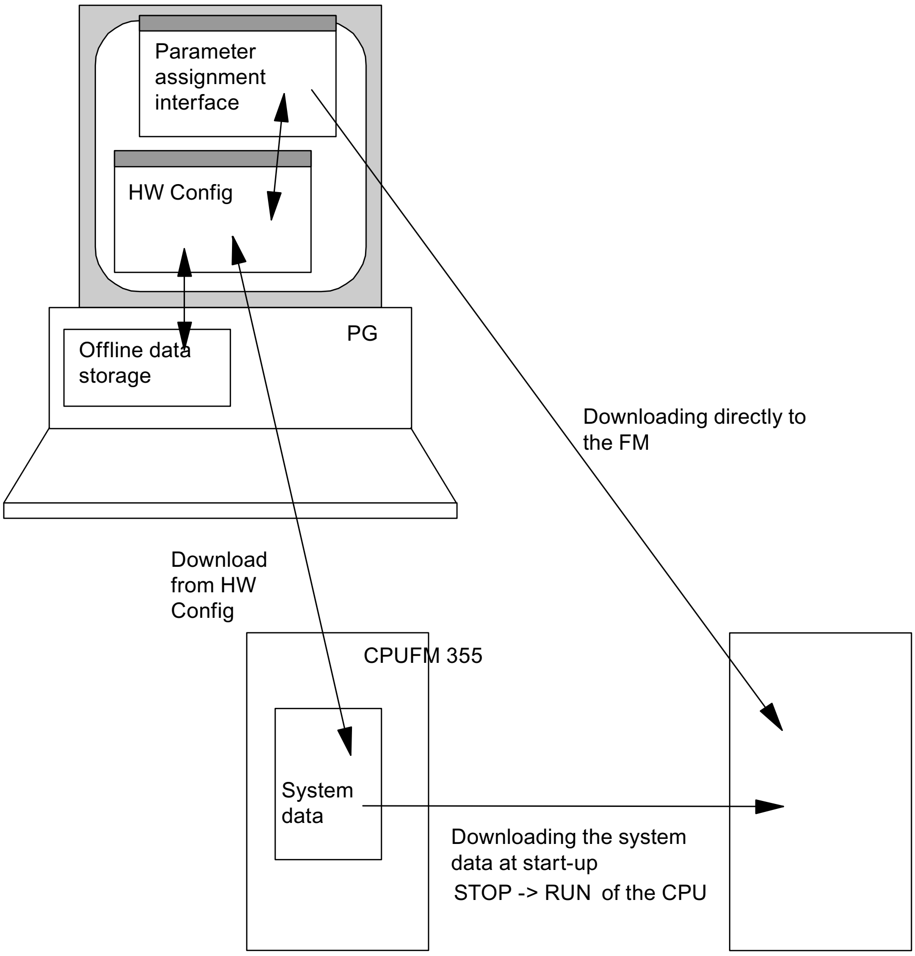


Figure 3-29 Parameter configuration of the FM 355 via the programming device and via the CPU

Connecting the FM 355 with the User Program

If you want to change controller parameters (for example controller gain, integration coefficient) of the FM 355 from a user program or by operation at the programming device, you have to use the PID_FM FB. You assign an instance data block to this FB for each control channel that you want to use. If the LOAD_PAR parameter is set when the PID_FM FB is called up via the user program, all the controller parameters of the FB are transferred to the FM 355. Controller parameters are all the parameters that lie after the cont_par variable in the instance data block.

The parameters in the instance DB have a default setting. These default settings can be modified using the STL/LAD editor.

Note

In order to ensure that you do not overwrite the parameters that you do not want to change by the default values from the instance DB, you must first call the PID_FM FB once with COM_RST = TRUE during the CPU start-up. The PID_FB FB then reads the parameters - that were transferred beforehand from the CPU into the FM - out of the FM 355 and places them in its instance DB. You can now change individual parameters and transfer all the parameters to the FM 355 with LOAD_PAR = TRUE.

Please note that the parameters in the FM 355 are always overwritten by the values from the system data whenever the CPU is started up (transition from STOP to RUN).

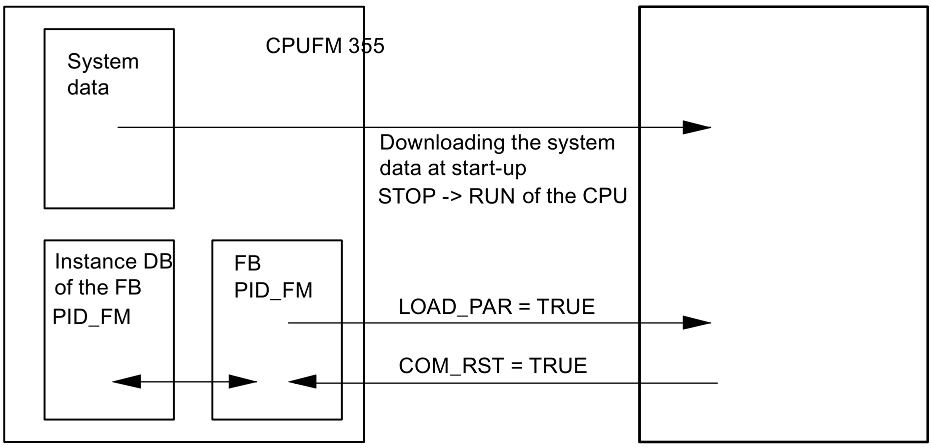


Figure 3-30 Parameter configuration of the FM 355 via system data and via the PID_FM FB

The operating parameters (for example setpoint, manual manipulated value) are transferred cyclically by the PID_FM FB to the FM 355. Operating parameters are all the parameters that lie between the op_par and cont_par variables in the instance data block.

To ensure this is possible without any great time expenditure in the CPU, the transfer takes place via direct peripheral access, not via the SFC WR_REC/SFB WRREC. Since only four bytes are available per channel in the I/O address area of the module, the data are multiplexed. It can therefore take up to three cycles of the CPU or of the FM 355 until the operating values have been transferred to the FM 355 – the respectively longer cycle is decisive.

If you set the parameter LOAD_OP = TRUE, then the operating parameters will be transferred to the module in a program cycle via the SFC WR_REC/SFB WRREC. However, this requires a higher run time (refer to the technical specifications).

The process values (for example, actual value, manipulated value) can also be read from the PID_FM FB via direct I/O accesses. This transfer requires less run time, but entails the functional limitations listed below. If the READ_VAR = TRUE parameter is set, then the process values are read from the FM 355 via the SFC RD_REC/SFB RDREC. However, this requires more run time.

Functional limitations if READ_VAR is not set:

- The SP (setpoint from the FM), ER (negative deviation), DISV (disturbance variable), LMN_A and LMN_B variables are not updated.
- The data are multiplexed. The actual value and manipulated value as well as the binary displays are not up-to-date until after the block has been called four times.
- If the setpoint and manual manipulated value were operated via the continuous-action controller, these operating values are not updated (read from the FM) during the start-up of the FB CPU.

Reference

Further information about using instance DBs is available in this documentation in the sections "Including the FM 355 in the User Program" and "Assignment of DBs".

See also

Parameter assignment (Page 6-2)

Summary (Page 7-1)

Instance DB of the PID_FM FB (Page 11-1)

Assignment of the DBs for Operator Control and Monitoring via OP (Page 11-35)

Operator Control and Monitoring of the FM 355 via the PID_FM FB

Operator control and monitoring of the FM 355 is possible via the PID_FM FB.

If one of the following parameters "Operating setpoint SP_OP, Operating manipulated value LMN_OP and the corresponding switches SP_OP_ON and LMNOP_ON" has been changed through OP control, the PID_FM FB takes over these values from the FM after the CPU start-up if the READ_VAR = TRUE parameter is set.

Operator Control and Monitoring of the FM 355 with the OP via MPI

You can establish a maximum of three connections from the FM 355 to OPs via MPI.

Operation of the FM 355 using the OP is only possible in the STOP state of the CPU or at a CPU failure.

Monitoring of the FM 355 with the OP is always possible.

The variable interface of the FM 355 contains four data blocks with the block numbers 101 to 104 for the controller channels 1 to 4 (refer to the following figure).

Note

The contents of Data blocks 101 to 104 do not automatically mirror the parameter value effective on the FM 355. Parameters changed using the OP are only taken over into the FM 355 after the LOAD_PAR or LOAD_OP operating bit has been set.

If you change a parameter using OP operation without setting the corresponding operating bit, the changed parameter value is entered in the data block, but the FM 355 continues to operate internally with the unchanged old value of the parameter.

After the operating bits have been set and the parameters taken over into the FM 355, the operating bits LOAD_PAR or LOAD_OP are reset by the FM 355.

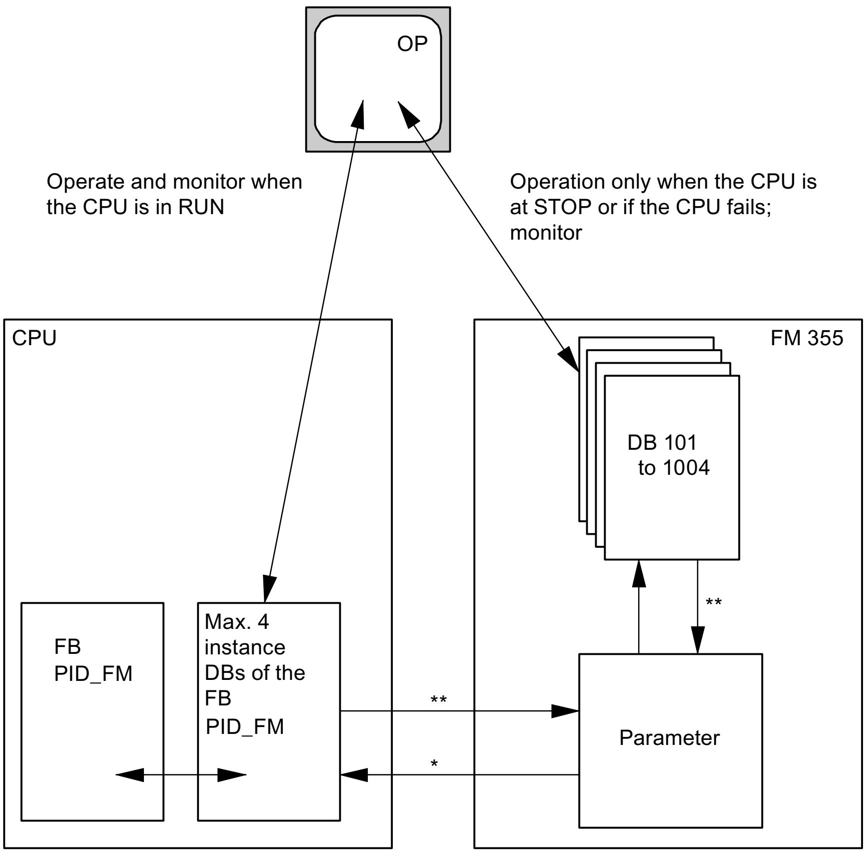


Figure 3-31 Operator control and monitoring of the FM.

* controlled by the READ_VAR parameter of the instance DB

** controlled by the LOAD_OP and LOAD_PAR parameters

3.7 Characteristics of the FM 355

Overview

The following topics contain information about

- The processing sequence and sampling time
- Rules for operation
- Startup reaction
- Backup mode
- Firmware update

Sequence of execution

The FM 355 executes the analog inputs and controller channels in a specified sequence. Each controller channel is executed immediately after the execution and conditioning of the analog input with the same number. Subsequently the analog input with the next highest number will be processed and so on. The reference junction is processed after controller channel 4. The following figure shows the sequence of execution of the FM 355.

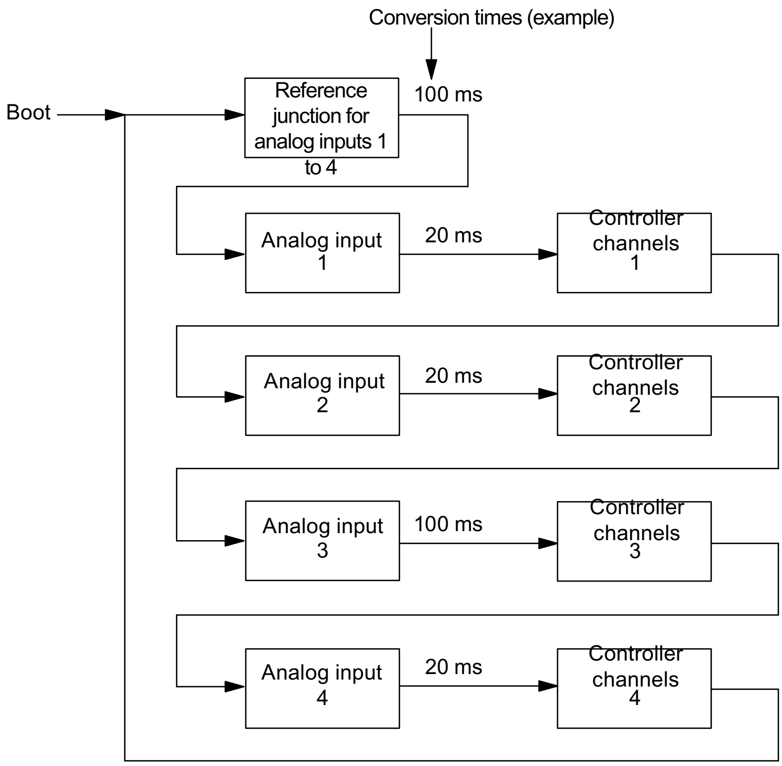


Figure 3-32 Sequence of execution of the FM 355 (four inputs used)

Sampling Time

The combined sampling time of all the controllers of the FM 355 results from the sum of the conversion times of the individual analog inputs. The conversion time for the reference junction is added, if it is used.

The conversion time of an analog input depends on the resolution, the line frequency and the controller type used:

Table 3-4 Conversion time of an analog input

Resolution	Line frequency	Controller type	Conversion time of an analog input
12 bits	60 Hz	No temperature controller	16 2/3 ms
12 bits	50 Hz	No temperature controller	20 ms
14 bits	50 or 60 Hz	No temperature controller	100 ms
12 or 14 bits	50 or 60 Hz	Temperature controller	100 ms

If an analog input is not executed, the controller channel with the same number is also not executed (conversion time = 0).

No additional conversion times result for the analog outputs. The analog output values of the FM 355 are output immediately after the corresponding output value has been calculated.

The following table contains further rules for the conversion time of the reference junction input.

Table 3-5 Rules for the conversion time

<table>
<tr><th>If ...</th><th>Then ...</th></tr>
<tr><td>A resolution of 12 bits is selected at all the analog inputs,</td><td>the reference junction requires the same conversion time as an analog input.</td></tr>
<tr><td>The higher resolution of 14 bits has been selected for even one analog input,</td><td rowspan="2">the reference junction requires a conversion time of 100 ms.</td></tr>
<tr><td>One of the controllers was configured as a temperature controller,</td></tr>
</table>

The sampling time is displayed in the parameter configuration interface: **Module parameters** command button.

The following sampling time results for each controller in the example shown in the previous figure (at 50 Hz line frequency):

t_{Sample} = 100 ms + 20 ms + 20 ms + 100 ms + 20 ms = 260 ms

The following figure shows an example of the sequence of execution at only three used analog inputs.

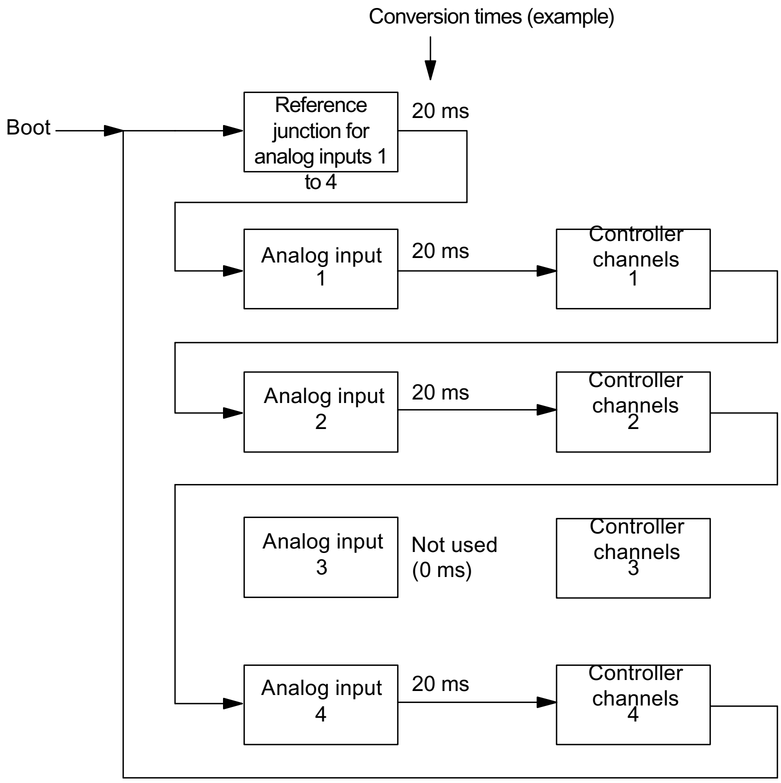


Figure 3-33 Sequence of execution of the FM 355 (three inputs used)

The following sampling time results for each controller in the example shown in the previous figure (at 50 Hz line frequency):

t_{Sample} = 20 ms + 20 ms + 20 ms + 0 ms + 20 ms = 80 ms

Rules for operating the FM 355

The following rules can be summarized for operation with the FM 355:

- The FM 355 controllers can be cascaded freely. This means that you can switch the manipulated value of a controller channel to the setpoint value of another controller channel.
- The execution of a controller channel is carried out immediately after the conditioning of the analog input with the same number.

  If a controller uses several analog inputs, you should select the controller channel whose number corresponds to the highest number of the used analog inputs in order to reduce the dead times.

  Example: A controller requires the signals of Analog inputs 1, 2 and 3. The smallest dead time results when Controller No. 3 is selected.
- If you select the setting "Analog input is not executed" at the analog input, the controller channel with the same number is then also not executed. No additional sampling time is thus required for this analog input.

- If the reference junction input is used, it requires the same conversion time as the analog input with the highest conversion time.
- The sampling time of a controller is the sum of the conversion times of the used analog inputs plus the conversion time of the reference junction input.

Startup Behavior

During the startup the FM 355 initially takes over the current parameters from its EEPROM and starts to control with these parameters. These are overwritten by the CPU with parameters from the system data as soon as the P-bus connection between the CPU and the FM 355 is established. If the system data do not contain any parameters for the controller, the module continues to control with the parameters stored in the EEPROM. A change to default parameters is unknown to the FM 355.

The following configurable options are available for the **manipulated value** for a restart after a power failure:

- The controller begins with the safety manipulated value.

  This setting remains effective until it is reversed by the user program via the function block.
- The controller goes into closed-loop control operation.

The following configurable options are available for the **setpoint value** for a restart after a power failure:

- The last valid setpoint value remains effective.
- A changeover to the safety setpoint value take place.

  This changeover is only effective if the setpoint value is specified by the user program via the function block. Otherwise the setpoint value is specified either by an analog input or by or controller output, depending on the parameter configuration.

Startup Behavior in an S7-300 and Own Power Supply of the FM 355

If the FM 355 in an S7-300 system has its own 24-V supply voltage that is independent of the CPU, the communication connection of the CPU to the FM 355 is interrupted after a failure and return of the 24-V supply voltage of the FM 355. This is indicated as follows:

- The RET_VALU output parameter has an error value in the PID_FM FB.
- The CPU does not change to the RUN state due to the "Parameter configuration error" error cause.

In order to restore the communication between the CPU and the FM 355, proceed as follows for the CPUs and devices listed below:

CPU/Device	Order No.:	Procedure
313	6ES7 313-1AD00-0AB0	Turn the power supply for the CPU off and on again.
314	6ES7 314-1AE00-0AB0 6ES7 314-1AE01-0AB0	
314 IFM	6ES7 314-5AE00-0AB0	
315	6ES7 315-1AF00-0AB0	
315-2 DP	6ES7 315-2AF00-0AB0	
614	6ES7 614-1AH00-0AB0	
C7 -623	6ES7 623-1AE00-0AE3 6ES7 623-1CE00-0AE3	
C7 -624	6ES7 624-1AE00-0AE3 6ES7 624-1CE00-0AE3	
C7 -626	6ES7 626-1AG00-0AE3 6ES7 626-2AG00-0AE3 6ES7 626-1CG00-0AE3 6ES7 626-2CG00-0AE3	

Proceed as follows at the CPUs listed below:

CPU	Order No.:	Procedure
313	6ES7 313-1AD01-0AB0	Change the CPU to the STOP state and then back to the RUN state.
314	6ES7 314-1AE02-0AB0	
314 IFM	6ES7 314-5AE01-0AB0	
315	6ES7 315-1AF01-0AB0	
315-2 DP	6ES7 315-2AF01-0AB0	
614	6ES7 614-1AH01-0AB0	

The technological function of the FM 355 is not influenced by this communication fault. In accordance with the parameter configuration the controllers of the FM 355 start up with one of the following operating states:

- Controller operation
  - Controlling with the safety setpoint value
  - Controlling with the last valid setpoint value
- Manipulated value = Safety manipulated value

Backup mode

If the CPU goes into STOP or fails or if the connection of the FM 355 to the CPU fails, the FM 355 goes into backup operation and continues to control with the parameters valid at the moment of failure. The FM 355 uses either the last setpoint value or the safety setpoint value. Depending on the parameter configuration.

Backup operation is indicated by the yellow "Backup" LED.

In backup operation the FM 355 can be operated directly via the OP. As soon as the CPU has returned to RUN, the FM 355 can no longer be operated via the OP.

See also

Functional mechanisms and data storage in the FM 355 (Page 3-30)

Firmware update

In order to extend the functionality and eliminate errors, firmware updates can be downloaded to the operating system memory of the FM 355. This functionality is described in the online help of the parameter configuration interface.

3.8 Parameter optimization with temperature controllers

Demands on the process in the case of temperature controllers

The process should fulfill the following requirements in order to achieve optimal control using the temperature controller:

- At bath heatings the liquid to be heated has to be mixed thoroughly.
- In case of bath-in-bath control systems both liquids have to be mixed thoroughly. At the same time good heat transitions between all the heat-transferring media have to be ensured. In the case of materials with poor heat-transferring properties large transfer surfaces should ensure good heat transportation.
- In case of room temperature control systems thorough mixing (for example with fans) has to be ensured.
- The controlling system gain may not exceed the factor of 3.
- The delay time may not exceed 3% of the recovery time.
- The temperature to be controlled should change by a maximum of 1‰ of the specified maximum temperature at the maximum manipulated value output within the sampling time of the controller.

Classification of the Controlled Systems

A controlled system or a process to be controlled is characterized by parameters such as the heat output, the heating mass or the heating capacity of the medium to be heated. With regard to the fuzzy controller a difference is made between "critical" and "non-critical" temperature controlled systems as follows: The control system becomes increasingly critical:

- The greater the heat output,
- the greater the heating capacity of the heating,
- The lower the heating capacity of the medium to be heated,
- the greater the heat transition resistance,
- the smaller the heat transfer surface.

After a manipulated value step change has been applied to the controlled system, it reacts with a step response. The controlled system can also be classified on the basis of this step response: The control system becomes increasingly critical the greater the ratio t_u / t_a is and the greater the controlled system gain is. With t_u / t_a < 1/10 you have a non-critical control section, refer to the following figure.

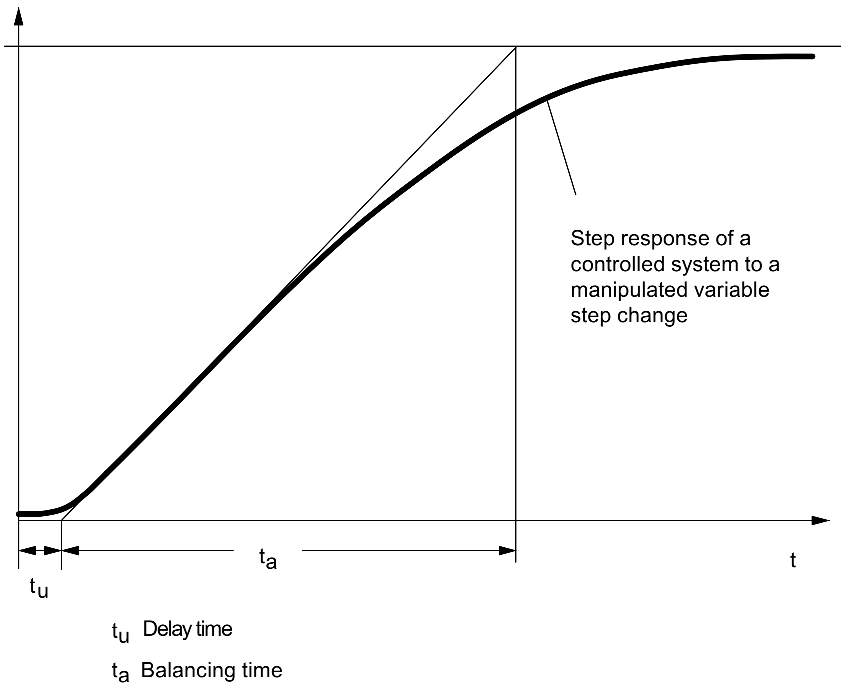


Figure 3-34 Step response of a controlled system to a manipulated value step change

Parameter Optimization at a Temperature Controller

Parameter optimization is based on a self-optimizing fuzzy controller.

In order for the temperature controller to operate optimally, the controlled system has to be identified. To this purpose the identification has to be activated by means of the FUZID_ON = 1 parameter in the instance DB of the PID_FM function block and a setpoint value step change of ≥12% of the maximum setpoint value carried out.

The identification of the controlled system begins with a monitoring phase during which no heat output takes place. The duration of the monitoring phase is as follows:

- Monitoring phase continuous controller: Approx. 1 min
- Monitoring phase step controller: Approx. 1 min + 1/2 x actuating time of final control element

This time is used in order to determine temperature trends in the heating medium. Afterwards the maximum heating output of 100% is output. This is visible at the LMN output parameter in the instance DB of the PID_FM function block.

The range of the first 4% of the temperature increase of the setpoint value range is used for the identification, whereby information about the process response is obtained at 1% and 4% respectively of the temperature increase on the basis of the time that has passed.

The identification is complete when the heating output becomes less than 100%. This behavior can be used, for example, to deactivate the identification via the user program. After the identification phase the controller continues to operate with the determined parameters.

A renewed identification is carried out at every further setpoint value step change ≥12% unless the identification has been deactivated again with FUZID_ON = FALSE.

If the setpoint value step change is not adjusted and if the heating output remains permanently at zero, the identification has been terminated unsuccessfully, meaning that the controller cannot control the connected controlled system.

Preconditions for the Identification

You have to ensure as far as possible that the controlled system has settled (no heating-up or cooling-down process) or is changing slowly and monotonously before the identification is carried out. The criterion can be that the temperature change is to approach a straight during a period of one minute. At faster processes this requirement is particularly relevant.

Since the manipulated variable zero is output for approx. one minute by the controller at the beginning of identification, the temperature to be controlled has to lie near the ambient temperature.

How To Start Identification

In order to start identification you first have to switch the controller to the optimization mode. This is done by setting the FUZID_ON bit in the instance DB of the PID_FM FB, either by the user program or via the parameter configuration tool:

Call: Test >Controller optimization

The identification is started by a positive setpoint value step change, whereby the following conditions have to be fulfilled:

- 1. Condition: The minimum step change size: Setpoint value step change > 5 degrees
- 2. Condition: The setpoint value after the step change:

  Setpoint value after > Actual value + Setpoint value limit x 0.12
  with setpoint value limit = Upper setpoint value limit of the controller

It is also possible to restart the identification by reducing and then increasing the setpoint value. The setpoint value has to fulfill Condition 2 after it has been increased.

Completing the Identification

As long as the bit FUZID_ON = TRUE, the next identification is started whenever the setpoint value step change is sufficiently large. We therefore recommend that the optimization mode be deactivated immediately after the identification has been completed (FUZID_ON = FALSE).

Information about the state of the identification is available through the IDSTATUS parameter of the CH_DIAG FB.

Canceling Identification

Identification can be canceled in the following cases:

- By the controller if a "critical" controlled system is identified. After canceling the controller is in the error state. This state is indicated by the fact that the manipulated variable is reset permanently by the controller. This is also not changed by deactivating the optimization. The error state is deleted by starting a new identification.

  Information about the state of the identification is available through the IDSTATUS parameter of the CH_DIAG FB.
- By the operator by generating a negative setpoint value step change, whereby the setpoint value must lie below that of Condition 2 (see above "How To Start identification").

Note

Deactivation of the optimizing mode with FUZID_ON=0 before identification has been completed does not stop the identification. An identification process that has been started continues to run under all circumstances – with the exception of a negative setpoint value step change.

Controller behavior with different control sections

Problems do not arise in case of an "uncritical" controlled system, neither during identification nor during controlling.

The identification of a controlled system that is "too critical" is cancelled. Controlling of an identified "critical" controlled system is carried out very "carefully" or slowly.

Controller State Information

The IDSTATUS parameter of the FB CH_DIAG function block supplies information about the identification state.

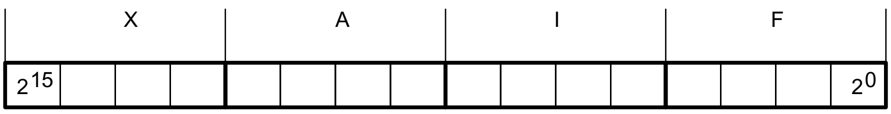


Figure 3-35 IDSTATUS parameter of the CH_DIAG FB

The IDSTATUS parameter contains the four hexadecimal values X, A, I and F. They have the following meaning:

X: Without meaning (always 0)

A: Action number:

0 = Manual operation (or no closed-loop control operation);

2 = Closed-loop control;

4 = Optimization activated (FUZID_ON = true);

6 = Transition state from manual operation to 2 or 4;

I: Display "Identification running" and "Parameters determined, but not yet stored in EEPROM"

0 = Identification not running, no new parameters determined

1 = Identification running, no new parameters determined

2 = Identification not running, new parameters determined, but not yet stored in EEPROM

3 = Identification running, new parameters determined, but not yet stored in EEPROM

F: Error number:

0 = No error

4 = Excessive step change of the actual value during the identification

5 = Ratio of delay time to system time constant too large or strongly non-linear behavior of the controlled system.

6= Temperature drop or rise during identification start too large. System not settled sufficiently

Installing and Removing the FM 355 4

4.1 Preparing for Installation

Determining the Slots

The FM 355 function module occupies two slots. It can be installed like a signal module in any of slots 4 to 11.

Mechanical Configuration

Manual /1/ describes the possibilities open to you for mechanical installation and how to proceed when configuring. The following gives only a few supplementary notes.

1. A maximum of eight SMs or FMs are permissible per rack.
2. The maximum number is restricted by the width of the modules or the length of your mounting rail. The FM 355 requires an installation width of 80 mm.
3. The maximum number is restricted by the total current consumptions of all modules to the right of the CPU from the 5 V backplane bus supply. The typical current input of the FM 355 from the 5 V backplane bus supply amounts to 50 mA.
4. The maximum number is also restricted by the memory required by the CPU software for communications with the FM 355.

Vertical or Horizontal Arrangement

The horizontal rack installation should be used if possible. For vertical installation, you must observe the restricted ambient temperatures (max. 40°C).

Determining the Start Address

The start address of the FM 355 is required for communication between the CPU and the FM 355. The start address has to be entered into the instance DBs of the required FBs.

The entry is made either by using the STL/LAD editor or from the user program.

The start address of the FM 355 can be determined in accordance with the same rules as the start address of an analog module.

Fixed Addressing

In fixed addressing the start address depends on the slot. The tables in Manual /1/ list the respective start address of an analog module at the various slots.

You can also calculate this fixed start address by using the following equation:

Adr. = 256 + (Rack No. x 128) + (Slot No. - 4) x 16

Free Addressing

In free addressing you specify the start address for the module under STEP 7.

Important Safety Rules

There are important rules you must observe for integrating an S7-300 with an FM 355 into a plant or a system. These rules and regulations are explained in Manual /1/.

Reference

Further information about addressing and configuring the instance DBs is available in this documentation in the sections "Including the FM 355 in the User Program" and "Assignment of DBs".

See also

Summary (Page 7-1)

4.2 Installing and Removing the FM 355

Precautions

No special protection measures (ESD guidelines) are required for installing an FM 355.

Tools Required

You require a 4.5 mm screwdriver to install and remove the FM 355.

Installing the FM 355

The following section describes how to install the FM 355 on the mounting rail. Manual /1/ contains further notes on installing modules.

1. Switch the CPU to STOP mode.
2. A bus connector is enclosed with the FM 355. Plug this into the bus connector of the module to the left of the FM 355. (The bus connector is located on the back and you may have to loosen the neighboring module.)
3. Hang the FM 355 onto the rail and swing it down.
4. Tighten the screw on the FM 355 (tightening torque approximately 0.8 to 1.1 Nm).

   If further modules are to be installed to the right of the FM 355, first connect the bus connector of the next module to the right-hand backplane bus connector of the FM 355.

   If the FM 355 is the last module in the rack, do not connect a bus connector.
5. Label the FM 355 with its slot number. Use the number wheel supplied with the CPU for this purpose.

   Manual /1/ describes the numbering scheme you must use and how to connect the slot numbers.
6. Install the shield contact element

Removing the FM 355 or Replacing a Module

The following section describes how to remove the FM 355. Manual /1/ contains further notes on removing modules.

1. Switch off the supply voltage L+ at the front connector.
2. Switch the CPU to STOP mode.
3. Open the front door panels. If necessary, remove the labeling strips.
4. Release the front connectors and pull them out.
5. Loosen the fixing screws on the module.
6. Swing the module out of the mounting rail and unhook it.
7. Install the new module if applicable.

Further Information

Manual /1/ contains further notes on installing and removing modules.

Wiring the FM 355

5

5.1 Terminal assignment of the front connectors

FM 355 C front connectors

The digital inputs, the analog inputs and outputs and the power supply of the module are connected via the two 20-pin front connectors of the FM 355 C.

The following figure shows the front of the module, a front connector and the inside of the front panels with the pin assignments.

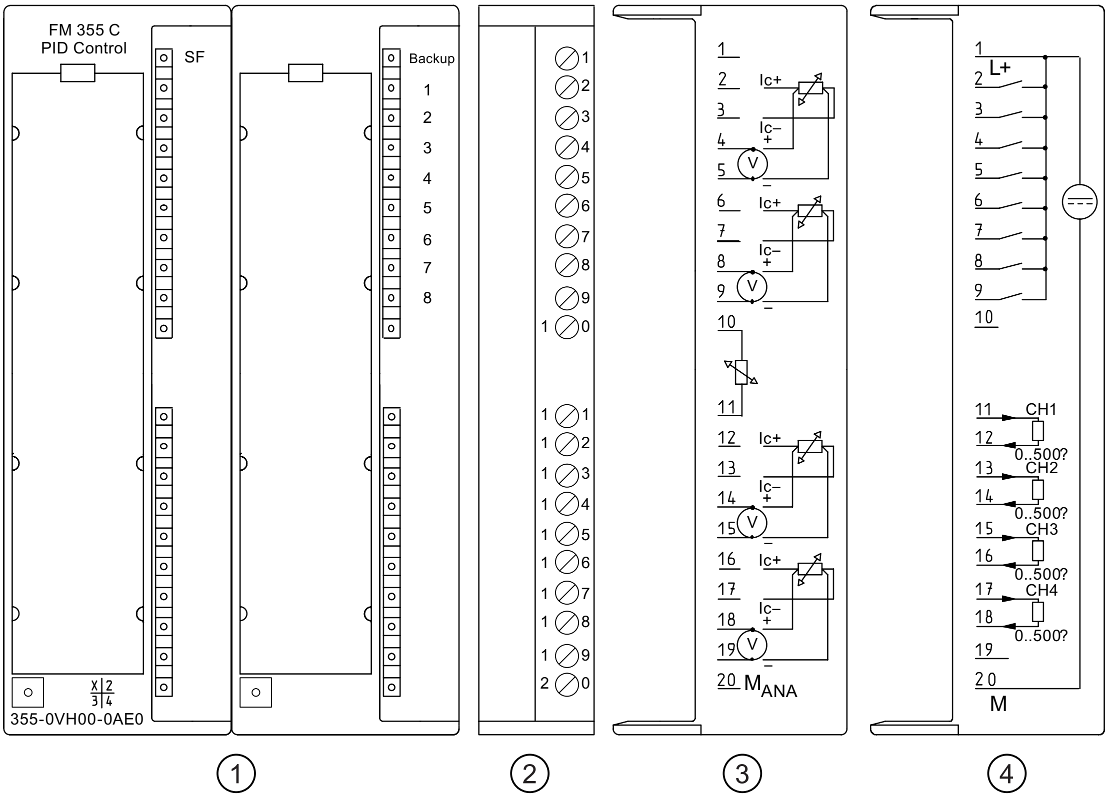


Figure 5-1 Terminal assignment of the front connectors of the FM 355 C

① Front view of the module

② Front connectors

③ Terminal assignment of the left-hand front connector

④ Terminal assignment of the right-hand front connector

Front Connector Assignment of the FM 355 C

Table 5-1 Terminal assignment of the front connectors of the FM 355 C

Left-hand front connector				Right-hand front connector			
Connection	Analog input	Name	Function	Connection	Analog output	Name	Function
1	–	–	–	1	–	L+	24 V DC supply voltage
2	1	IC+	Constantcurrent line (pos.)	2	–	I1	Digital input
3		IC–	Constantcurrent line (neg.)	3	–	I2	Digital input
4		M+:	Measuring line (pos.)	4	–	I3	Digital input
5		M–	Measuring line (neg.)	5	–	I4	Digital input
6	2	IC +:	Constantcurrent line (pos.)	6	–	I5	Digital input
7		IC–	Constantcurrent line (neg.)	7	–	I6	Digital input
8		M+:	Measuring line (pos.)	8	–	I7	Digital input
9		M–	Measuring line (neg.)	9	–	I8	Digital input
10	–	COMP+	Reference junction input (pos.)	10	–	–	–
11	–	COMP–	Reference junction input (neg.)	11	1	Q1	Analog output
12	3	IC +:	Constantcurrent line (pos.)	12		M_{ANA}	Reference point of the analog circuit
13		IC–	Constantcurrent line (neg.)	13	2	Q2	Analog output
14		M+:	Measuring line (pos.)	14		M_{ANA}	Reference point of the analog circuit
15		M–	Measuring line (neg.)	15	3	Q3	Analog output
16	4	IC +:	Constantcurrent line (pos.)	16		M_{ANA}	Reference point of the analog circuit
17		IC–	Constantcurrent line (neg.)	17	4	Q4	Analog output
18		M+:	Measuring line (pos.)	18		M_{ANA}	Reference point of the analog circuit
19		M–	Measuring line (neg.)	19	–	–	–
20	–	M_{ANA}	Reference point of the analog circuit	20	–	M	Mass of the supply voltage 24 V DC

Note

The M_{ANA} connections have to be connected with low impedance to the central ground connection. If you supply the encoders externally, you must also connect the ground of this external voltage with the ground of the CPU.

FM 355 S front connectors

The analog inputs, the digital inputs and outputs and the power supply of the module are connected via the two 20-pin front connectors of the FM 355 S.

The following figure shows the front of the module, a front connector and the inside of the front panels with the pin assignments.

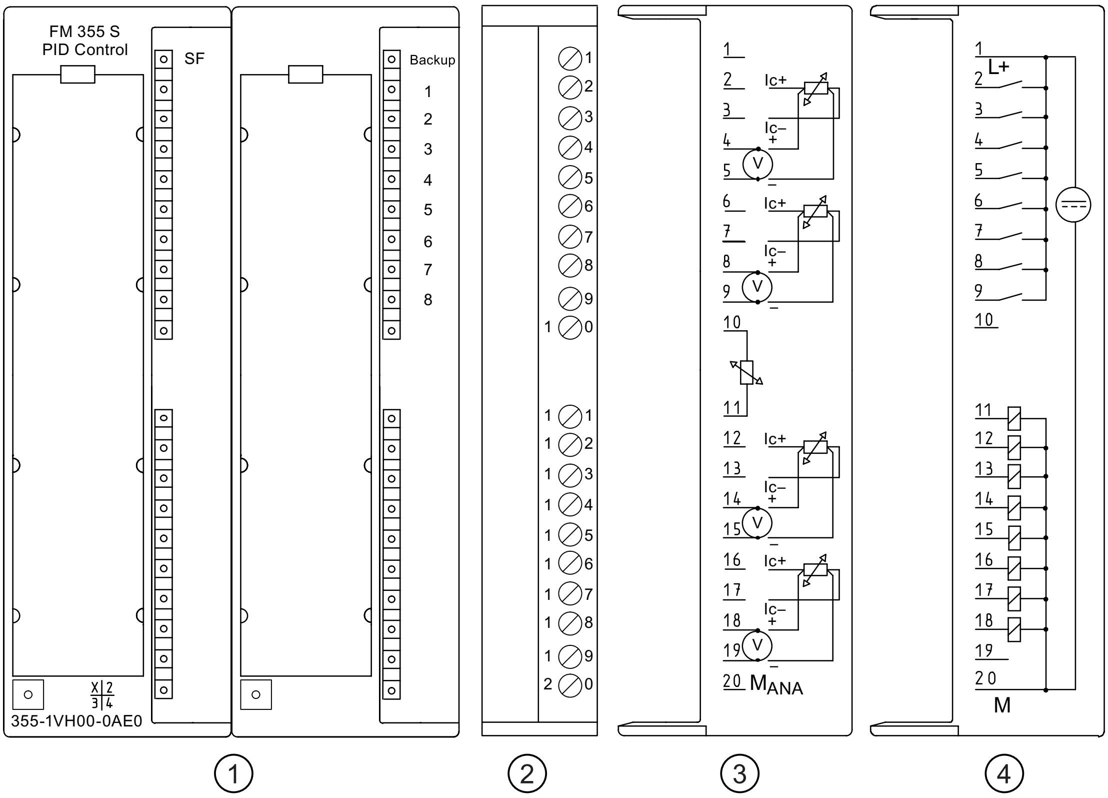


Figure 5-2 Terminal assignment of the front connectors of the FM 355 S

①	Front view of the module
②	Front connectors
③	Terminal assignment of the left-hand front connector
④	Terminal assignment of the right-hand front connector

Front Connector Assignment of the FM 355 S

Table 5-2 Terminal assignment of the front connectors of the FM 355 S

Left-hand front connector				Right-hand front connector			
Con-nection	Analog input	Name	Function	Con-nection	Con-troller chan-nel	Name	Function
1	–	–	–	1	–	L+	24 V DC supply voltage
2	1	IC +:	Constantcurrent line (pos.)	2	–	I1	Digital input
3		IC–	Constantcurrent line (neg.)	3	–	I2	Digital input
4		M+:	Measuring line (pos.)	4	–	I3	Digital input
5		M–	Measuring line (neg.)	5	–	I4	Digital input
6	2	IC +:	Constantcurrent line (pos.)	6	–	I5	Digital input
7		IC–	Constantcurrent line (neg.)	7	–	I6	Digital input
8		M+:	Measuring line (pos.)	8	–	I7	Digital input
9		M–	Measuring line (neg.)	9	–	I8	Digital input
10	–	COMP +:	Reference junction input (pos.)	10	–	–	–
11	–	COMP –	Reference junction input (neg.)	11	1	Q1	Digital output At step controllers: Manipulated value signal up At pulse controllers: Manipulated value A
12	3	IC +:	Constantcurrent line (pos.)	12		Q2	Digital output At step controllers: Actuating Signal Down At pulse controllers: Manipulated value B
13		IC–	Constantcurrent line (neg.)	13	2	Q3	Digital output At step controllers: Manipulated value signal up At pulse controllers: Manipulated value A
14		M+:	Measuring line (pos.)	14		Q4	Digital output At step controllers: Actuating Signal Down At pulse controllers: Manipulated value B
15		M–	Measuring line (neg.)	15	3	Q5	Digital output At step controllers: Manipulated value signal up At pulse controllers: Manipulated value A

Left-hand front connector				Right-hand front connector			
Con-nection	Analog input	Name	Function	Con-nection	Con-troller chan-nel	Name	Function
16	4	IC +:	Constantcurrent line (pos.)	16		Q6	Digital output At step controllers: Actuating Signal Down At pulse controllers: Manipulated value B
17		IC–	Constantcurrent line (neg.)	17	4	Q7	Digital output At step controllers: Manipulated value signal up At pulse controllers: Manipulated value A
18		M+:	Measuring line (pos.)	18		Q8	Digital output At step controllers: Actuating Signal Down At pulse controllers: Manipulated value B
19		M–	Measuring line (neg.)	19	–	–	–
20	–	M_{ANA}	Reference point of the analog circuit	20	–	M	Mass of the supply voltage 24 V DC

Note

The M_{ANA} connection has to be connected with low impedance to the central ground connection. If you supply the encoders externally, you must also connect the ground of this external voltage with the ground of the CPU.

Supply voltage L+/M

Connect a direct voltage of 24 V to the L+ and M terminals for the power supply of the modules and of the digital outputs.

Caution

Only extra low voltage ≤ 60 V DC separated safely from the system may be used for the 24 V DC power supply. Safe isolation can be implemented by one of the following requirements:

- VDE 0100 Part 410 / HD 384-4-41 / IEC 364-4-41 (as functional low voltage with safe isolation)
- VDE 0805 / EN 60950 / IEC 950 (as safety extra-low voltage SELV)
- VDE 0106 Part 101

An integral diode protects the module from reverse polarity of the supply voltage.

Input Filters for Digital Inputs

In order to suppress disturbances, digital inputs I1 to I8 have input filters (RC elements) with a uniform filter time of 1.5 ms.

Digital outputs

The FM 355 S disposes of eight digital outputs, Q1 to Q8, that are used to directly trigger control processes.

The digital outputs are supplied via the supply voltage L+.

The digital outputs are source outputs and can be loaded with a load current of 0.1 A. They are protected from overload and short-circuit.

Note

Direct connection of inductivities (such as relays and contactors) is possible without external circuiting. If SIMATIC output circuits can be deactivated by additionally installed contacts (for example relay contacts), you have to provide additional overvoltage protection devices at inductivities (see the following example for overvoltage protection).

Overvoltage Protection Example

The following figure shows an output circuit that requires additional overvoltage protection devices.

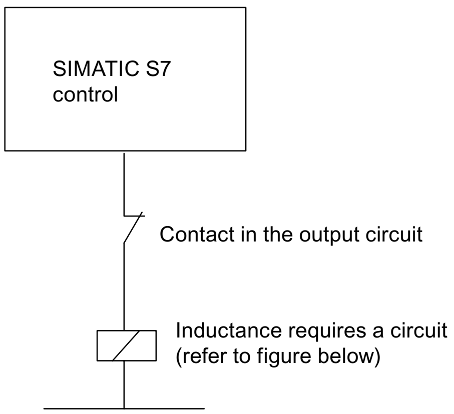


Figure 5-3 Relay contact in the output circuit

Circuiting of Coils Operated with DC Voltage

Direct-current coils are circuited with diodes or Zener diodes.

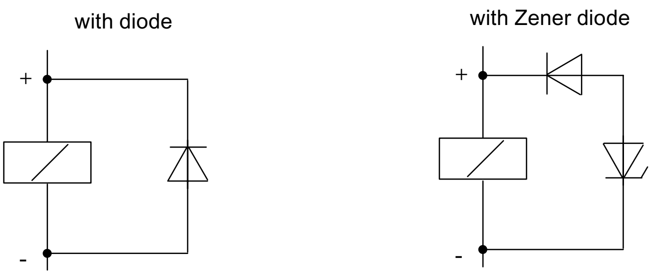


Figure 5-4 Circuiting of coils operated with DC voltage

Wiring with diodes / Zener diodes

Diode/Zener diode circuits have the following characteristics:

- Opening overvoltages can be avoided totally. Zener diodes have higher interruption voltages.
- Long switch-off delay (6 to 9 times longer than without a protective circuit). Zener diodes switch off faster than diode circuits.

5.2 Wiring front connectors

Cables

Here are some rules for you to observe when selecting cables:

- The cables for Digital inputs I1 to I8 have to be shielded if the length exceeds 600 m.
- The cables for the analog signals have to be shielded.
- You must apply the shields of the analog signal cables both at the encoder and in the immediate vicinity of the module via the shield contact element, for example.

The following figure shows details for the connection of analog signals.

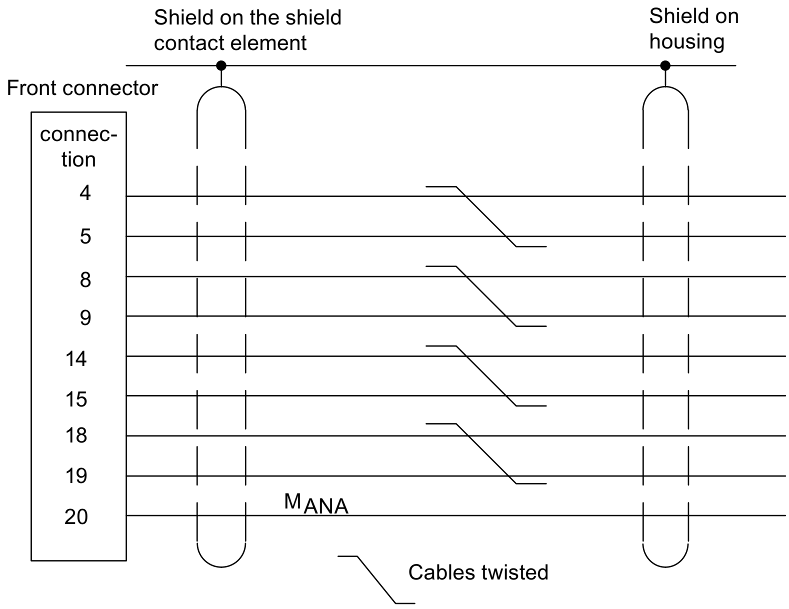


Figure 5-5 Connection of analog signals

Terminal 20 (M_{ANA}) of the front connector has to be connected with low impedance to the CPU ground. If you supply the encoder with an external voltage, you must also connect the ground of this external voltage with the CPU ground.

- Use flexible cables with cross-sections of 0.25 to 1.5 mm^2.
- You do not need wire end ferrules. If you use wire end ferrules then use only those without insulation collar in accordance with DIN 46228 Form A, short version!

Note

Analog inputs that are not used are to be short-circuited and connected to M_{ANA}.

Wiring

Proceed as follows when wiring the front connector:

1. Place the front connector in the wiring position and open the front panel.
2. Strip the conductors (length 6 mm).
3. Do you want to use end ferrules?

   If yes: Press the end ferrules and the cables together.
4. Feed the enclosed strain relief clamp into the front connector.
5. If the wires leave the module at the bottom, begin wiring at the bottom, otherwise begin at the top. Also screw tight unassigned terminals (tightening torque 0.6 to 0.8 Nm).
6. Tighten the strain relief clamp for the cable chain.
7. Push the front connector into the operating position.
8. Apply the cable shields to the shield contact element or to the shield bar.
9. Label the terminals on the labeling strip.

The following figure shows the module with the shielded cables and the shield contact element.

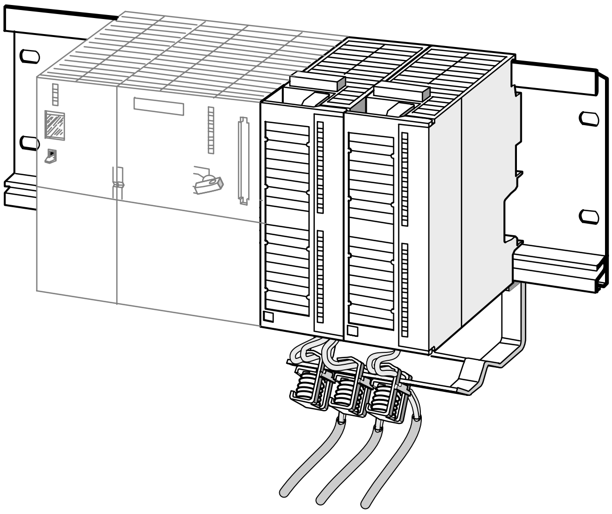


Figure 5-6 Connection of the shielded cables to the FM 355

5.3 Module Status After First Being Switched On

Characteristics

The state in which the module is after the power supply has turned on and when data have not been transferred yet (state of delivery) is characterized by the following:

- Analog inputs: No execution
- Analog outputs (continuous-action controller): 0 mA
- Digital outputs (step controller): Zero (deactivated)
- No controller active
- Diagnostic interrupt disabled

6 Parameter Configuration of the FM 355

6.1 Installing the Parameterization Interface

Prerequisites

STEP 7 must be correctly installed on your PG / PC.

Delivery format

The software is delivered on CD ROM.

Procedure

To install the software:

1. Place the CD in the CD drive of your PG / PC.
2. Under Windows 95 / NT, launch the dialog for installing software by double-clicking on the "Software" icon in "Control panel".
3. In the dialog box, select the CD drive and then the **setup.exe** file and start installation process.
4. Follow the on-screen step-by-step instructions of the installation program.

The following will be installed on your PG / PC:

- Parameterization interface
- Function blocks
- Program examples
- Online help

Program examples

The program examples can be found in the STEP 7 catalog in the sub-catalog "Examples" in the project FM_PIDEx.

Reading the Readme file

Important up-to-date information about the provided software can be found in a Readme file. This file is located in the start window of the SIMATIC Manager.

6.2 Configuring the hardware

Procedure

Configuration assumes that you have set up a project in which you can save the configuration. Refer to the *Basic Software for S7 and M7, STEP 7* user manual for more information on configuring modules. The following briefly explains the most important steps.

1. Launch the SIMATIC Manager and then call the configuration table in your project.
2. Select a subrack and arrange this.
3. Open the subrack.
4. Select the FM 355 from the module catalog.
5. Drag the FM 355 to the respective line of the configuration table.
6. From the configuration table, note the input address of the module, e.g. 272.

   The value that you read off is displayed in decimal format.

6.3 Parameter assignment

Procedure

After configuration, you can start with the parameter assignment.

When assigning parameters you set the module parameters.

1. Double click on the order number of the module in the configuration table or select the module and use the menu command **Edit > Object properties**.

   Result: You end up in the "Properties" dialog box.
2. Click on the "Basic parameters" tab.

   Result: You end up in the "Basic parameters" dialog box.
3. Parameterize the basic parameters of the module.
4. Click on "Parameter ...".

   Result: You end up in the parameterization interface.
5. Parameterize the module and save the parameters entered with **File > Save**.
6. End the parameterization interface:
7. Save your project in the HW Config with **Station > Save and compile**.
8. Transfer the parameter data with the CPU in STOP mode by selecting **Target system > Load > Project**.

   Result: The data is located in the CPU´s memory and will be directly transferred from there to the module.
9. Carry out a CPU start-up.

What you should note with parameterization.

The controller module checks the parameters only to the point at which a secure module function is guaranteed. This applies, e.g. for parameters that are used for address generation, as well as for time-dependent variables (e.g integration time constants > half scanning time). When the controller module detects a parameterization error, then an entry is made in the DS0 and DS1 of the module and the red error LED lights up. You can read off parameterization errors in the **Target system > Parameterization error display** menu of the parameterization interface.

Further tests for established thresholds or plausibility (e.g. upper limit > lower limit) are not carried out.

In the parameterization interface you can select the assignment between inputs and controller channels as well as between controller channels and outputs. Note the following:

Note

The parameterization tool does not provide an error message if when assigning the controller channels to the inputs you assign two channels to one input.

Integrated help

Included in the parameterization interface is an integrated help that supports you in the parameterization of the controller module. You have the following possibilities of calling the integrated help:

- Via the menu command **Help > Help topics ...**
- By pressing the F1 key
- By clicking on the help button in the individual parameterization screens

The integrated help´s description of the parameterization of the module goes into more detail than that of the manual.

See also

Diagnostics Records DS0 and DS1 (Page 12-2)

Implementing the FM 355 in the User Program 7

7.1 Summary

Overview

The following topics contain all the information required to program the FM 355 in the S7-300.

Seven STEP 7 blocks are provided in order to implement the FM 355 in a user program. These allow simple handling of the desired functions.

This chapter describes the following blocks:

- PID_FM FB for operator control and monitoring via the CPU as well as online modification of controller parameters
- FB FUZ_355 for reading and writing the parameters of all temperature controllers of the FM 355. The block enables a fast adaptation of the controller to changes in the control section, and a parameterization of the temperature controllers after a module replacement or new identification.
- FORCE355 FB for simulation (forcing) of the analog and digital input value (to support commissioning).
- READ_355 FB for reading out the digital and analog input values (to support commissioning).
- A CH_DIAG FB for reading out further channel-specific parameters (to support commissioning)
- The FB 39 PID_PAR for changing other parameters online.
- The FB 40 CJ_T_PAR for changing the configured reference junction temperature online.

Note

FB 39 and FB 40 from the FM_PID "FM 355, 455 PID Control" library do not run under S7 300 CPUs with a Micro Memory Card. If you use a CPU with a PROFINET connection, take the respective blocks from the FM_PID "FM 355 PROFINET" library, otherwise you must use the FB 29 and the FB 30.

You will find the description of the FB 29 and FB 30 blocks in the Appendix.

7.2 The function block PID_FM

Use

The FM 355 is connected to the user program by means of the PID_FM FB. With this FB you can change operating parameters during operation. You can, for example, specify a setpoint value and the manipulated value or switch over to external manipulated value specification.

The data required for the PID_FM FB are stored in an instance DB on the CPU. The PID_FM FB reads data program-controlled from the FM 355 and writes data program-controlled to the FM 355.

The individual parameters are described in the online help and in the "Assignment of DBs" section.

Creating and Supplying an Instance DB

Before you program the module with the user program, you have to create an instance DB and supply it with important data for each controller channel that you want to use.

1. Use STEP 7 to create the instance DBs for the controller channels as data blocks with an assigned PID_FM function block.
2. Enter the module address in the MOD_ADDR parameter at every instance DB.

   The module address of the FM 355 is specified during the configuration of your hardware. Take over the start address from HW Config.
3. Enter the channel number of the corresponding controller channel (1, 2, 3, or 4) in the CHANNEL parameter at every instance DB.
4. Save the instance DBs.

Call

The PID_FM FB has to be called in the same OB as all the other FBs that access the same FM 355.

The PID_FM FB is normally called in the watchdog interrupt OB 35. It requires an initialization run that is started by setting the COM_RST = TRUE parameter in the start-up of the CPU. Calling of an FB in the start-up OB is possible, but not necessary. After the initialization run the PID_FM FB sets the COM_RST parameter to FALSE.

7.2.1 Operator Control via the PID_FM FB

Transfer of the Operating Parameters

The operating parameters (for example setpoint, manual manipulated value) are transferred cyclically by the PID_FM FB to the FM 355. Operating parameters are all the I/O parameters that lie between the op_par and cont_par parameters in the instance data block of the function block.

In order to allow data transfer without high run times in the CPU, transfer is normally (when LOAD_OP = FALSE) carried out via direct I/O accesses. Since only four bytes are available per channel in the I/O address area of the module, the data are multiplexed. It can therefore take up to three cycles of the CPU or of the FM 355 until the operating values have been transferred to the FM 355 and become effective there – the respectively longer cycle is decisive.

If you want the operating values to be transferred immediately (in one cycle of the CPU or of the FM 355) to the FM 355, you can set the LOAD_OP parameter to TRUE. The transmission then takes place by means of SFC WR_REC/SFB RDREC, the FB requires more time for this (refer to Appendix A.2 "Technical specifications of function blocks"). After a successful data transfer the LOAD_OP parameter of the PID_FM FB is reset to FALSE. This can take a few call cycles if the FM 355 is used in distributed I/Os.

7.2.2 Monitoring via the PID_FM FB

Reading the Process Values

The FB PID_FM cyclically reads the process values (e.g. process value, manipulated variable) from the FM 355. Process values are all the output parameters of the function block after the out_par parameter.

The PID_FM FB also reads the process values via direct I/O accesses if READ_VAR = FALSE. This transfer requires less run time, but entails the functional limitations listed below.

If the READ_VAR = TRUE parameter is set, then the process values are read from the FM 355 via the SFC RD_REC/SFB RDREC. However, this requires a higher run time (refer to the technical specifications). After a successful data transfer the READ_VAR parameter of the PID_FM FB is reset to FALSE. This can take a few call cycles if the FM 355 is used in distributed I/Os.

Function at READ_VAR = TRUE

If one of the following parameters "Operating setpoint SP_OP, Operating manipulated value LMN_OP and the corresponding switches SP_OP_ON" and "LMNOP_ON" has been changed through OP control, the PID_FM FB takes over these values from the FM 355 after the CPU start-up.

Functional Limitiations at READ_VAR = FALSE

- The SP (setpoint from the FM), ER (negative deviation), DISV (disturbance variable), LMN_A and LMN_B parameters are not read from the FM.
- The data are multiplexed. The actual value, manipulated value and binary displays are updated during every fourth call of the block.
- If the setpoint and manual manipulated value were operated via the MPI, these operating values are not read from the FM during the start-up of the FB CPU.

Note

Multiplexing of the data to be transferred during access to the FM 355 via direct I/O accresses is controlled via the PID_FM FB. This multiplex controlling does not function if two instances of the PID_FM FB access the same channel number of a module. This results in incorrect parameters in the FM 355 (for example setpoint value and manual manipulated value) and incorrect displays of the PID_FM FB at its output parameters.

Error Displays

The output parameter, RET_VALU, contains the feedback value RET_VAL of the SFCs RD_REC and WR_REC. With the blocks for PROFINET operation, the RET_VAL includes the 2nd and 3rd bytes of the STATUS parameter of the SFB RDREC and WRREC. RET_VAL can be evaluated if the parameters READ_PAR and LOAD_PAR are not reset. The values of RET_VALU are described in the reference manual /2/.

An I/O access error can occur when the PID_FM FB is called, if the FM 355 is not plugged or is not supplied with voltage. In this case the CPU changes to STOP mode if no OB 122 is loaded in the CPU.

See also

Instance DB of the PID_FM FB (Page 11-1)

7.2.3 Changing Controller Parameters Using the PID_FM FB

Procedure

Controller parameters (such as controller gain, integration coefficient) are all the I/O parameters that lie after the cont_par parameter in the instance DB of the function block. Controller parameters are first configured via the parameter configuration interface and transferred via the system data to the FM 355.

Changing controller parameters using the PID_FM FB is advisable if you want to change these during operation depending on the process states. Proceed as follows:

1. Set the COM_RST parameter of the FB PID_FM to TRUE in the start-up of the CPU.

   The FB then reads **all** the controller parameters from the FM 355 and places them in its instance DB. The instance DB of the PID_FM FB is now compared with the parameters of the parameter configuration interface (system data). After successful reading of the parameters the PID_FM FB sets the COM_RST parameter to FALSE. This can take a few call cycles if the FM 355 is used in distributed I/Os.

2. If COM_RST = FALSE, you can now change individual controller parameters in the instance DB of the PID_FM FB in the user program.

   To do so call the PID_FM FB by setting LOAD_PAR = TRUE. The PID_FM FB then transfers **all** the controller parameters from the instance DB to the FM. After successful transfer of the parameters the PID_FM FB resets the LOAD_PAR parameter. This can take a few call cycles if the FM 355 is used in distributed I/Os.

Note

Please note that the parameters in the FM 355 are always overwritten by the values from the system data whenever the CPU is started up (transition from STOP to RUN).

See also

Operator Control and Monitoring of the FM 355. (Page 3-33)

7.2.4 Changing controller parameters via the OP

Procedure

If you want to change controller parameters of the PID_FM FB at the OP, proceed as follows:

1. Write the parameters that are to be changed from the OP into an auxiliary DB (see ①).
2. Do not transfer these parameters that are to be changed from the auxiliary DB into the instance DB of the PID_FM FB until **after** the initialization of the PID_FM FB triggered by COM_RST = TRUE (see ②) has been carried out (see ③).
3. Transfer the parameters to the controller module by setting LOAD_PAR (see ④).

Storage of the parameters in an auxiliary DB is necessary, because, after the start-up of the CPU with COM_RST = TRUE, the PID_FM FB reads those parameters from the module that the CPU had transferred beforehand from the system data to the FM.

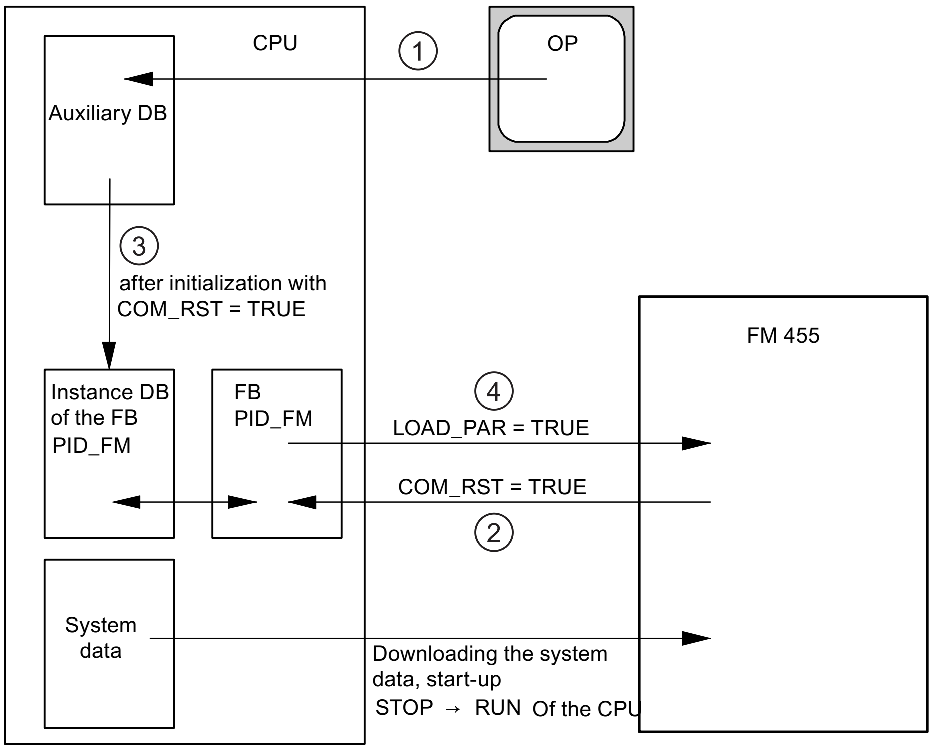


Figure 7-1 07_01_Changing controller parameters via OP

If COM_RST = TRUE is set, the CHANNEL parameter is also checked. If an invalid channel number was configured at the CHANNEL parameter, the outputs QMOD_F and QCH_F are set, COM_RST remains set and no further action of the FB is carried out.

If no error is found during the check and the parameters were read successfully from the module, the COM_RST parameter is reset by the PID_FM FB.

Note

If the FB is called at the first call with COM_RST = FALSE and an invalid channel number is configured at the MOD_ADDR or CHANNEL parameters, the FB accesses an incorrect I/O address without any further check.

7.2.5 Saving the parameters in EEPROM

Principle

In the case of program-controlled reconfiguration (LOAD_PAR, LOAD_OP) of the controller module by the FB PID_FM, the time thereof increases. The new parameters are always immediately effective and are also stored in a non-volatile memory (EEPROM). After saving the parameters in the EEPROM, any resaving is delayed by 30 minutes as the life span of the EEPROM is restricted by the number of write operations. After recovery of the supply voltage, it is possible to immediately save new parameters in EEPROM. Whether the reconfiguration of the controller module takes place by the FB PID_FM shock-free depends on the choice of the parameters.

7.2.6 Relationship between FB parameters and the parameterization interface

Overview

The following figures show the relationship between the PID_FM FB and the parameter configuration interface of the controller module.

The parameters act at the same point at three-component controllers and ratio/blending controllers as at fixed setpoint or cascade controllers. This also applies for the parameters that exist equally at continuous-action controllers, at controllers with a pulse output as well as at step controllers. As a rule the same command buttons also contain the same parameters. Therefore, in order to obtain a clearly structured overview not all the structure screens are shown and not all the parameters are drawn in all the screens.

However, the parameters of the PID_FM FB are contained in all the figures – with the exception of the parameters MOD_ADDR, CHANNEL, QMOD_F, QPARA_F, QCH_F, QLMNR_ON, RET_VALU, COM_RST, LOAD_PAR, READ_VAR, LOAD_OP.

At which points do the parameters of the PID_FM FB act?

The following figures show at which points in the module the parameters of the PID_FM FB act.

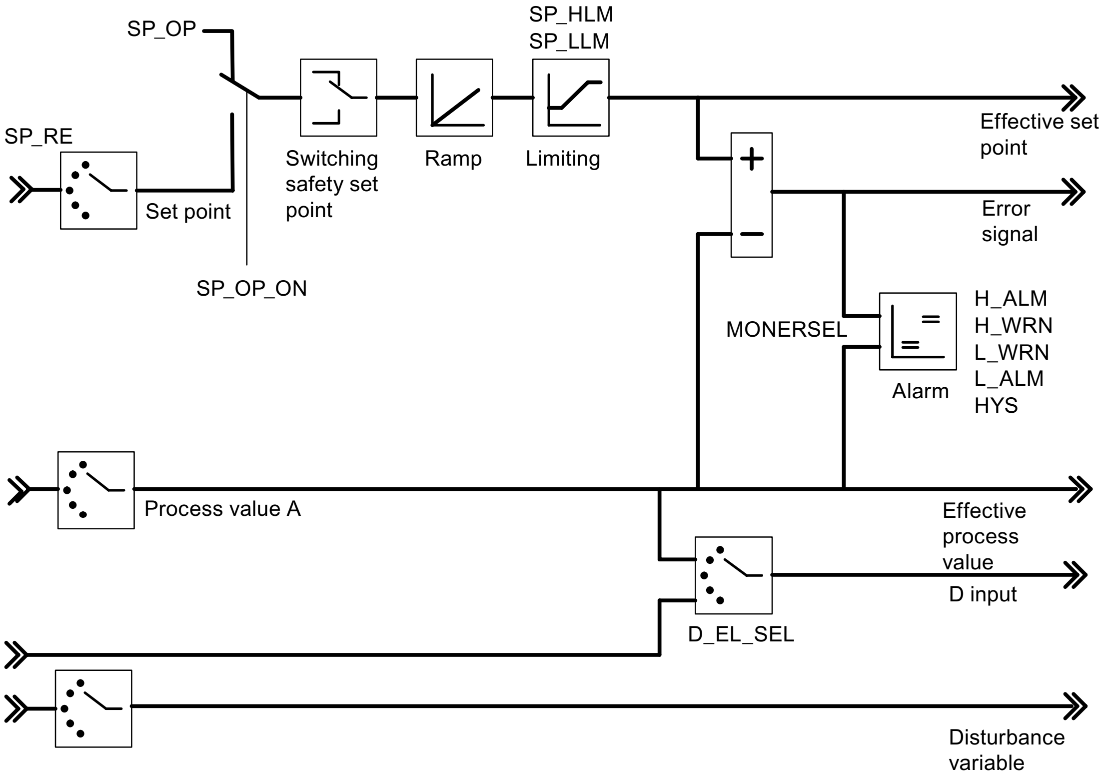


Figure 7-2 Negative deviation generation at fixed setpoint or cascade controller

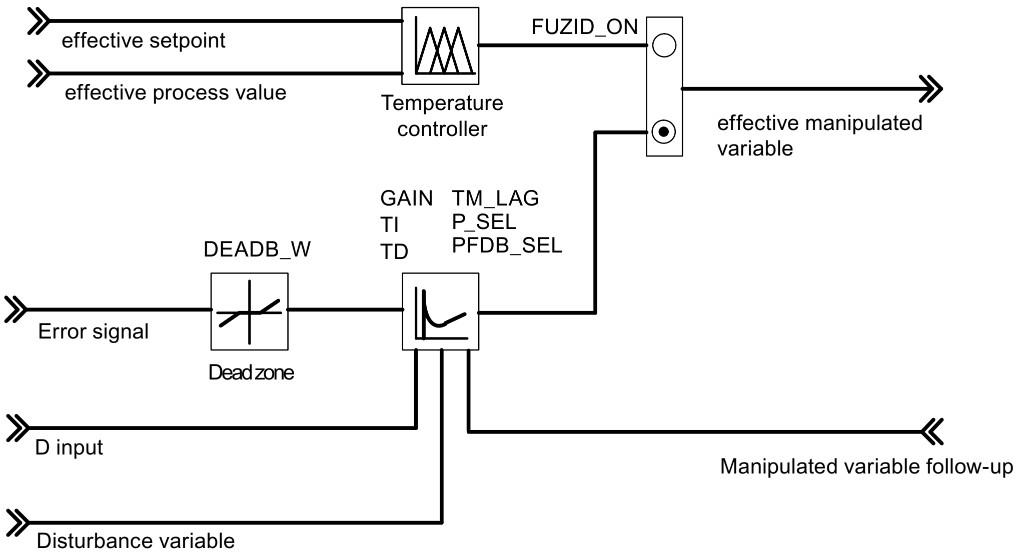


Figure 7-3 Block diagram of the control algorithm

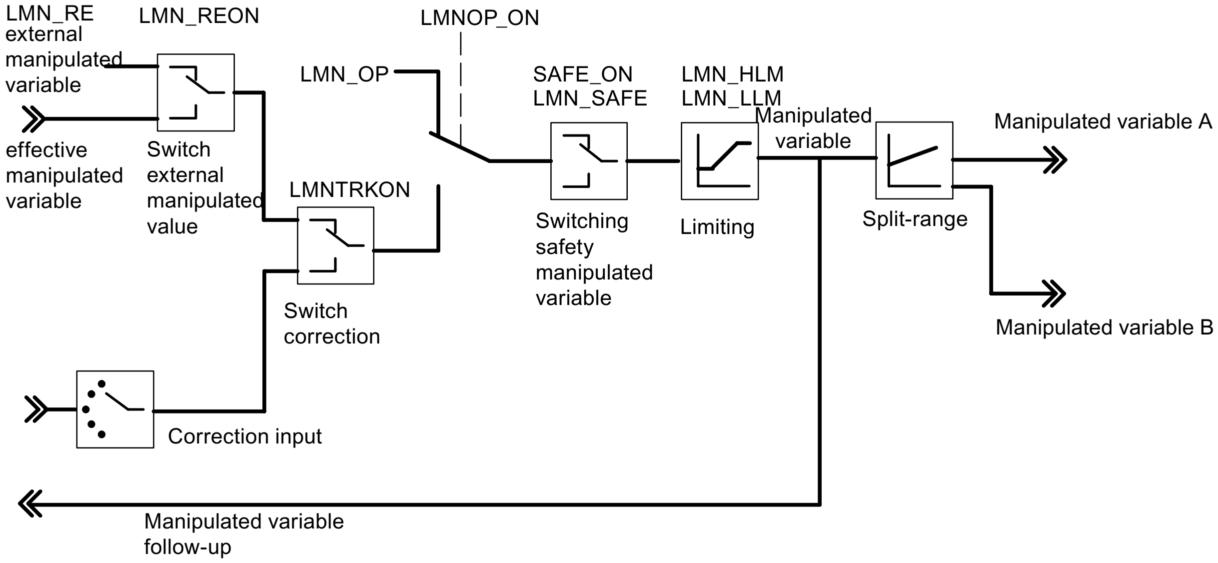


Figure 7-4 Controller output of the continuous-action controller

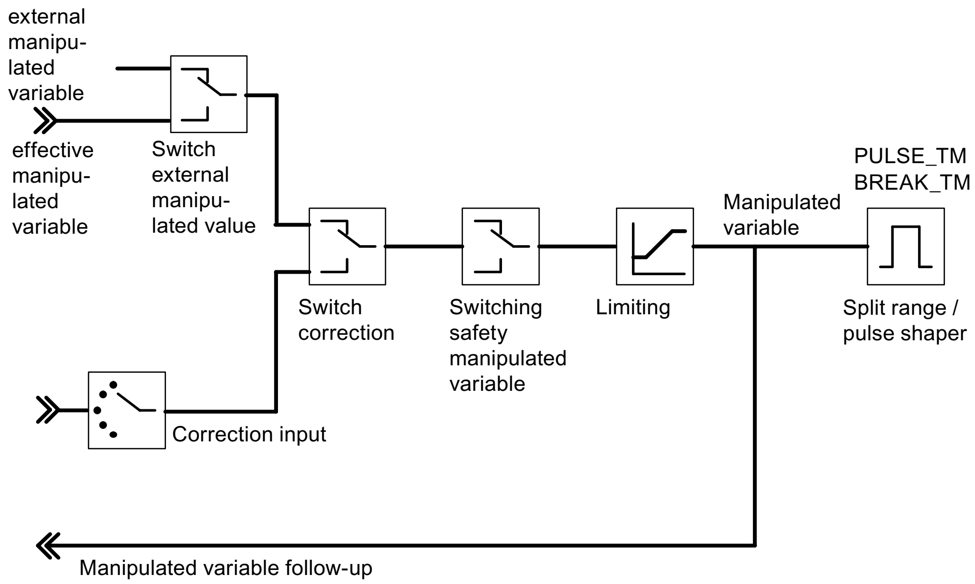


Figure 7-5 Controller output of the step controller (pulse controller operating mode)

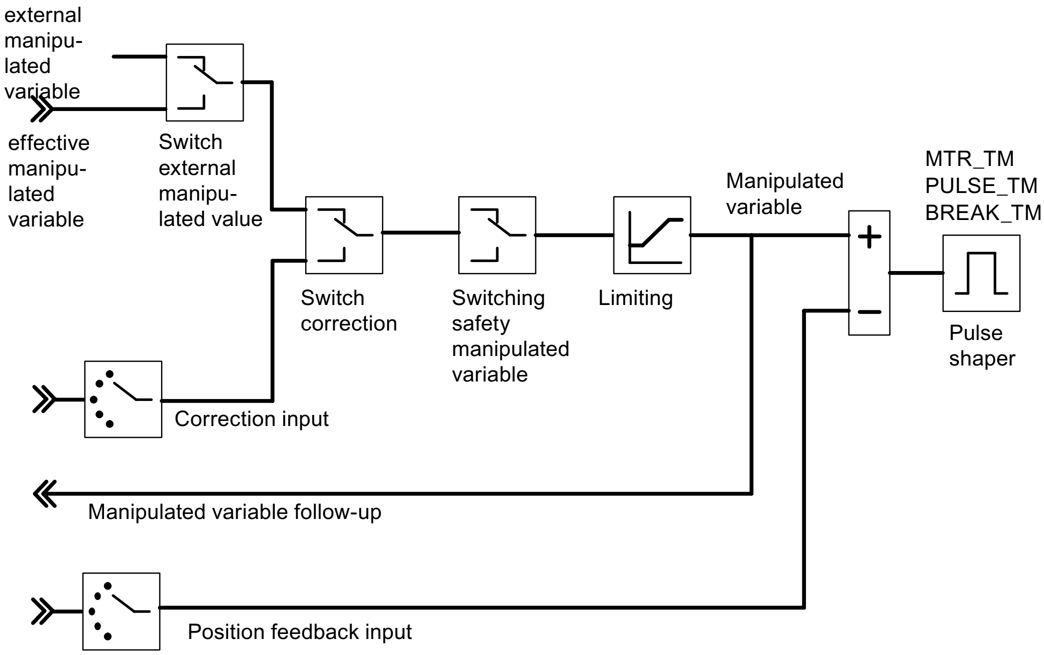


Figure 7-6 Controller output of the step controller (step controller operating mode with position feedback)

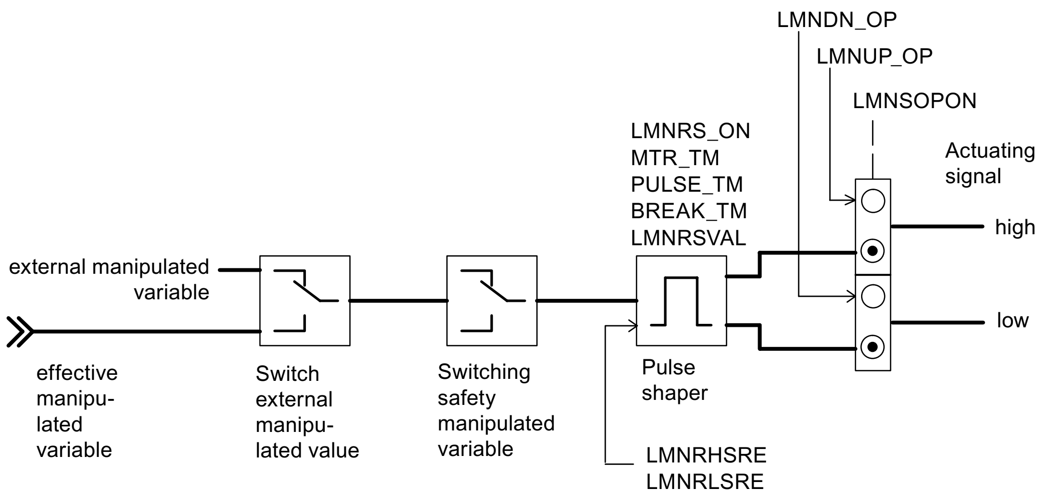


Figure 7-7 Controller output of the step controller (step controller operating mode without position feedback)

At which points are the parameters of the PID_FM FB generated?

The following figures show at which points in the module the output parameters of the PID_FM FB are generated.

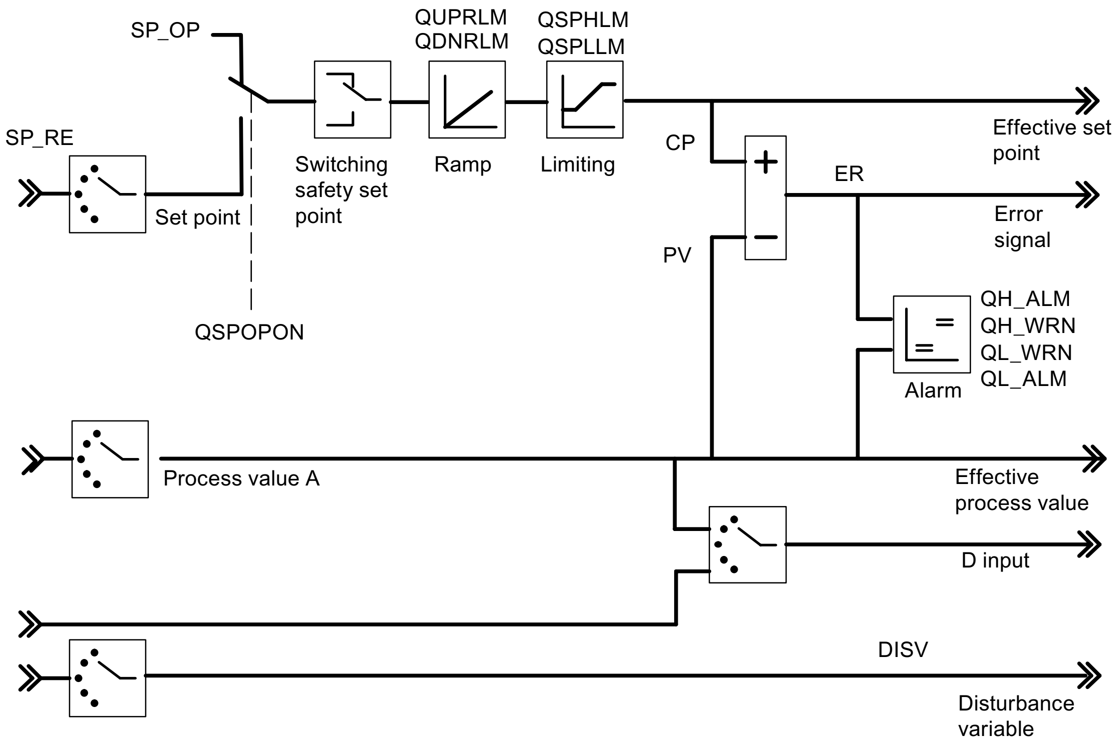


Figure 7-8 Negative deviation generation at fixed setpoint or cascade controller

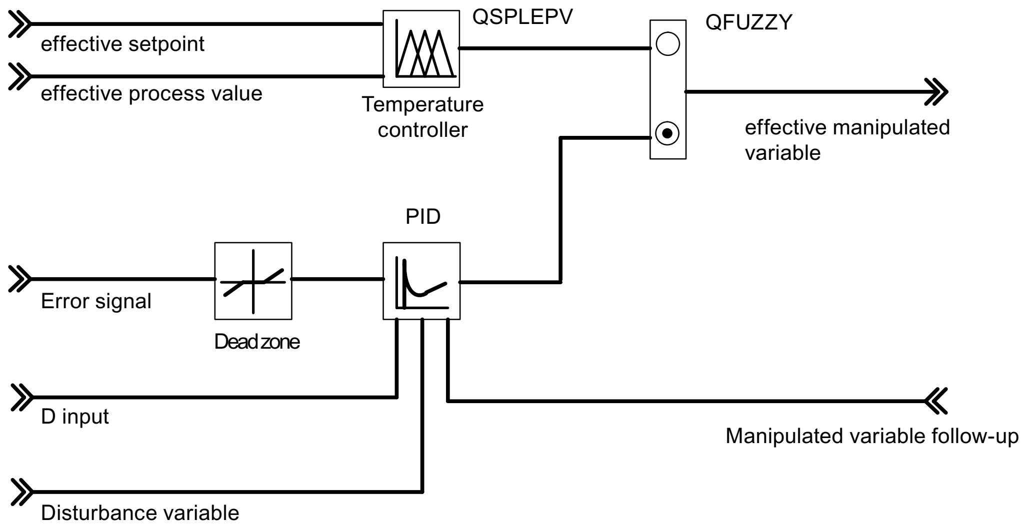


Figure 7-9 Block diagram of the control algorithm

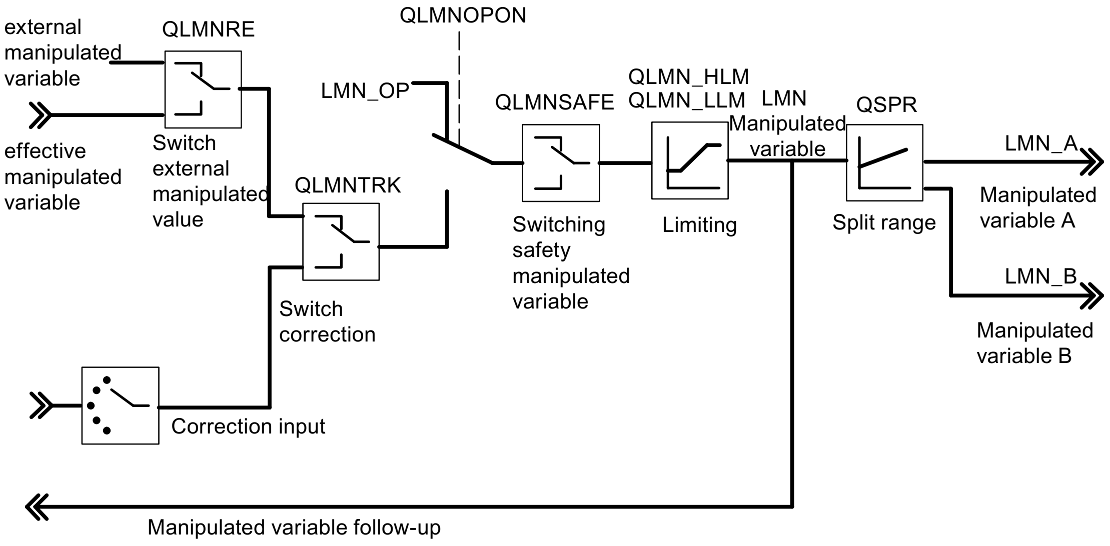


Figure 7-10 Controller output of the continuous-action controller

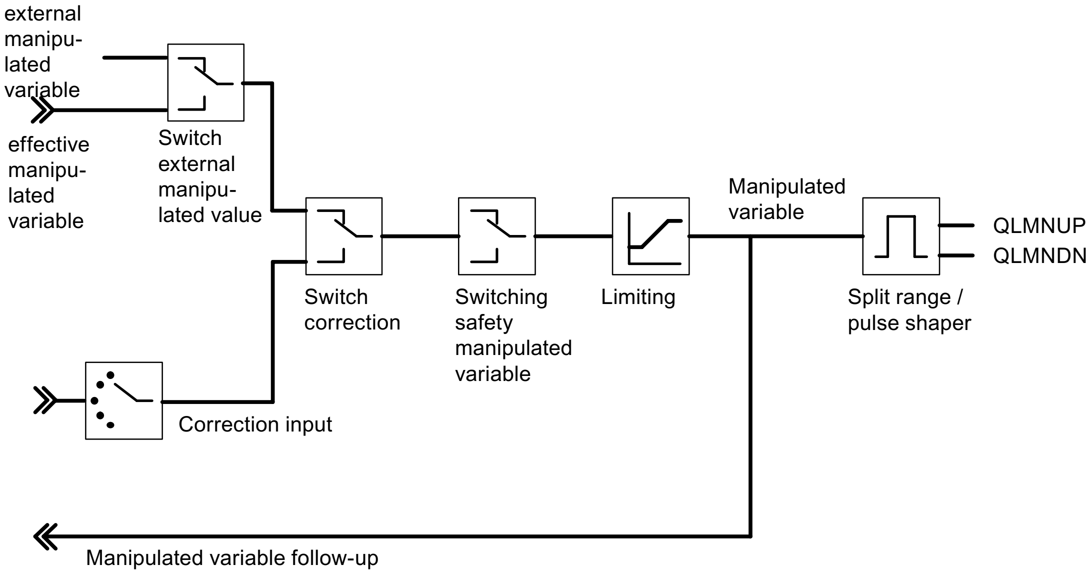


Figure 7-11 Controller output of the step controller (pulse controller operating mode)

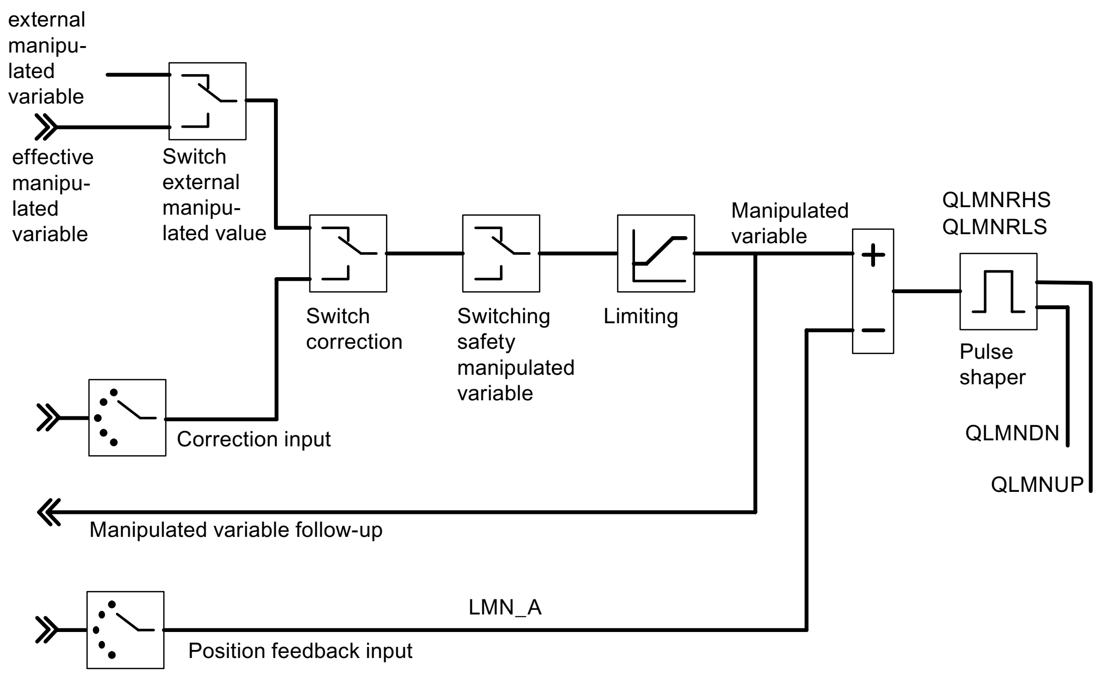


Figure 7-12 Controller output of the step controller (step controller operating mode with position feedback)

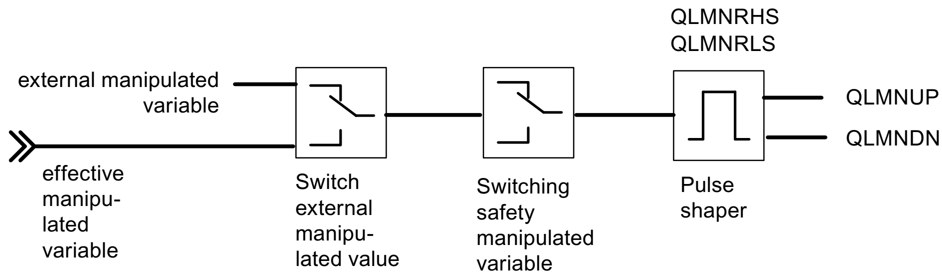


Figure 7-13 Controller output of the step controller (step controller operating mode without position feedback)

See also

Instance DB of the PID_FM FB (Page 11-1)

7.3 The FUZ_355 function block

Use

The FUZ_355 FB is used for the temperature controller of the FM 355 (fuzzy controller). This FB can be used to read and write the parameters of all the temperature controllers of the FM 355. This function is suitable for the following applications:

- Transfer of the controller parameters determined through identification to the FM 355 after module replacement
- Adapting the FM 355 to different controlled systems

Note

You may not change the parameters determined through identification by the FM 355 since they have been optimized for the process.

The FUZ_355 FB does not require an initialization run.

Creating and Supplying an Instance DB

Before you program the module with the user program, you have to create an instance DB and supply it with important data.

1. Use STEP 7 to create the instance DB as a data block with an assigned FUZ_355 function block.
2. Enter the module address in the MOD_ADDR parameter at the instance DB.

   The module address of the FM 355 is specified during the configuration of your hardware. Take over the start address from HW Config.
3. Save the instance DB.

Call

The FUZ_355 FB has to be called in the same OB as all the other FBs that access the same FM 355.

Using the FM FUZ_355

When you have carried out an identification of the temperature controllers and the controllers control with satisfactory results, call the FUZ_355 FB and set the READ_PAR parameter to TRUE.

The FB then reads the parameters of all four temperature controllers of the FM 355 and places them in the instance DB. After the temperature controller parameters have been read out successfully, the FUZ_355 FB sets the READ_PAR parameter to FALSE. This can take a few call cycles if the FM 355 is used in distributed I/Os. You should therefore call the FB conditionally after READ_PAR has been set as long as READ_PAR = TRUE.

You should set the LOAD_PAR parameter of the FUZ_355 FB in the start-up of the CPU and then call the block conditionally in the cyclic program as long as LOAD_PAR = TRUE. If the LOAD_PAR = TRUE parameter is set, then the FB writes the parameters of all the temperature controllers of the FM 355 from the instance DB to the FM 355. After a successful transmission of the parameters, the FB PID_FM sets the LOAD_PAR parameter to FALSE. This can take a few call cycles if the FM 355 is used in distributed I/Os.

When the temperature controller parameters are read, a parameter configuration error of the temperature controller parameters is displayed in the PARAFFUZ parameter as follows:

High byte of PARAFFUZ not euqal to zero means that a parameter configuration error exists. The low byte contains the byte offset of the incorrect parameter, referenced to the beginning of the static variables. For example, PARAFFUZ = W#16#0104 means that the second parameter is incorrect.

The error display can only be displayed if you manipulate the temperature controller parameters in the instance DB and write to the FM 355. You can also read out these parameter assignment errors by using the **PLC > Parameter Assignment Error** menu of the parameter configuration interface.

The output parameter, RET_VALU, contains the feedback value RET_VAL of the SFCs RD_REC and WR_REC. With the blocks for PROFINET operation, the RET_VAL includes the 2nd and 3rd bytes of the STATUS parameter of the SFB RDREC and WRREC. RET_VALU can be evaluated if the parameters READ_PAR and LOAD_PAR are not reset. The values of RET_VALU are described in the reference manual /2/.

See also

Instance DB of the FUZ_355 FB (Page 11-20)

7.4 The FORCE355 function block

Use

The FORCE355 FB is used to simulate (force) the analog and digital input values to support commissioning.

The FORCE355 FB does not require an initialization run. It is normally called cyclically.

Creating and Supplying an Instance DB

Before you program the module with the user program, you have to create an instance DB and supply it with important data.

1. Use STEP 7 to create the instance DB as a data block with an assigned FORCE355 function block.
2. Enter the module address in the MOD_ADDR parameter at the instance DB.

   The module address of the FM 355 is specified during the configuration of your hardware. Take over the start address from HW Config.
3. Save the instance DB.

Call

The FORCE355 FB has to be called in the same OB as all the other FBs that access the same FM 355.

Simulating Analog Values

Simulation of the analog values for channels one to four is activated via the switches S_AION[i] or S_PVON[i], whereby $1 \leq i \leq 4$. The following figure shows at which point the simulated analog value is effective.

The simulation values for the channels one to four are specified via the parameters PV_SIM[i].

You can have the simulation values become effective at two points:

- S_AION[i] = TRUE ($1 \leq i \leq 4$)

  The value PV_SIM[i] is used instead of the value of analog input i of the module.
- S_PVON[i] = TRUE ($1 \leq i \leq 4$)

  The value PV_SIM[i] is used instead of the conditioned value of analog input i of the module.

Simulating Digital Values

Simulation of the values for the digital inputs one to eight is activated via the switches S_DION[i], whereby 1 ≤ i ≤ 8.

The simulation values are specified via the parameters DI_SIM[i].

- S_DION[i] = TRUE (1 ≤ i ≤ 8)

  The value DI_SIM[i] is used instead of the value of digital input i of the module.

Note

LEDs I1 to I8 also always display the state of the corresponding digital input during simulation.

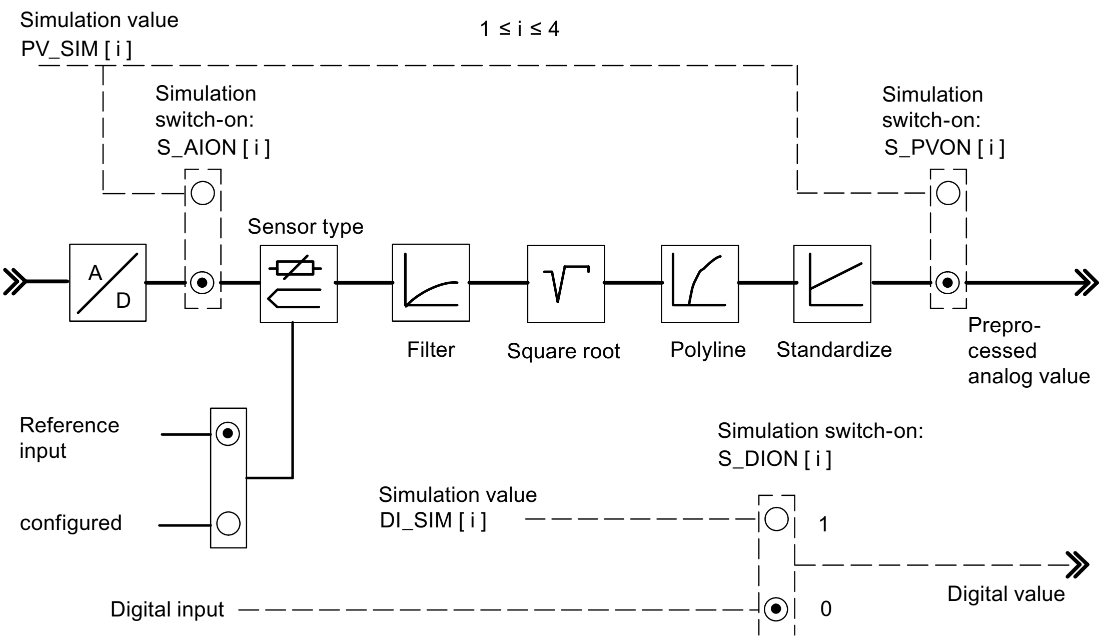


Figure 7-14 Effect of simulation values

At a restart of the FM 355 after a power-off the simulation switches on the FM 355 are positioned again to FALSE.

The output parameter, RET_VALU, contains the feedback value RET_VAL of the SFCs RD_REC and WR_REC. With the blocks for PROFINET operation, the RET_VAL includes the 2nd and 3rd bytes of the STATUS parameter of the SFB RDREC and WRREC. The values of RET_VALU are described in the reference manual /2/.

Note

Activation and specification of the simulation values (forcing) is not carried out via the parameter configuration interface. The corresponding switches and connecting lines are therefore drawn dashed.

See also

Instance DB of the FB FORCE355 (Page 11-23)

7.5 The READ_355 function block

Use

The READ_355 FB is used to read out the digital and analog input values to support commissioning.

The READ_355 FB does not require an initialization run. It is normally called cyclically.

Creating and Supplying an Instance DB

Before you program the module with the user program, you have to create an instance DB and supply it with important data.

1. Use STEP 7 to create the instance DB as a data block with an assigned READ_355 function block.
2. Enter the module address in the MOD_ADDR parameter at the instance DB.

   The module address of the FM 355 is specified during the configuration of your hardware. Take over the start address from HW Config.
3. Save the instance DB.

Call

The READ_355 FB has to be called in the same OB as all the other FBs that access the same FM 355.

Displayed values

The following values are displayed:

- The CJ_TEMP parameter shows the reference junction temperature measured at the reference junction in degrees C or in degrees F (depending on the temperature unit that was configured). If no "Thermocouple" sensor type was configured or if the configured reference junction temperature was selected at all the analog inputs, 0.0 is displayed at the CJ_TEMP parameter.
- The actual states of digital inputs 1 to 8 are displayed at parameters STAT_DI[1] to STAT_DI[8], even if these are simulated.
- The values of analog inputs 1 to 4 are displayed at parameters DIAG[1].PV_PER to DIAG[4].PV_PER in the unit mA or mV respectively. If the simulation of the analog input value is activated via the FORCE355 FB, the simulated value is displayed.

- The values of analog inputs 1 to 4 are displayed at parameters DIAG[1].PV_PER to DIAG[4].PV_PER in the unit mA or mV respectively. If the simulation of the conditioned physical analog input value is activated via the FORCE355 FB, the simulated value is displayed.

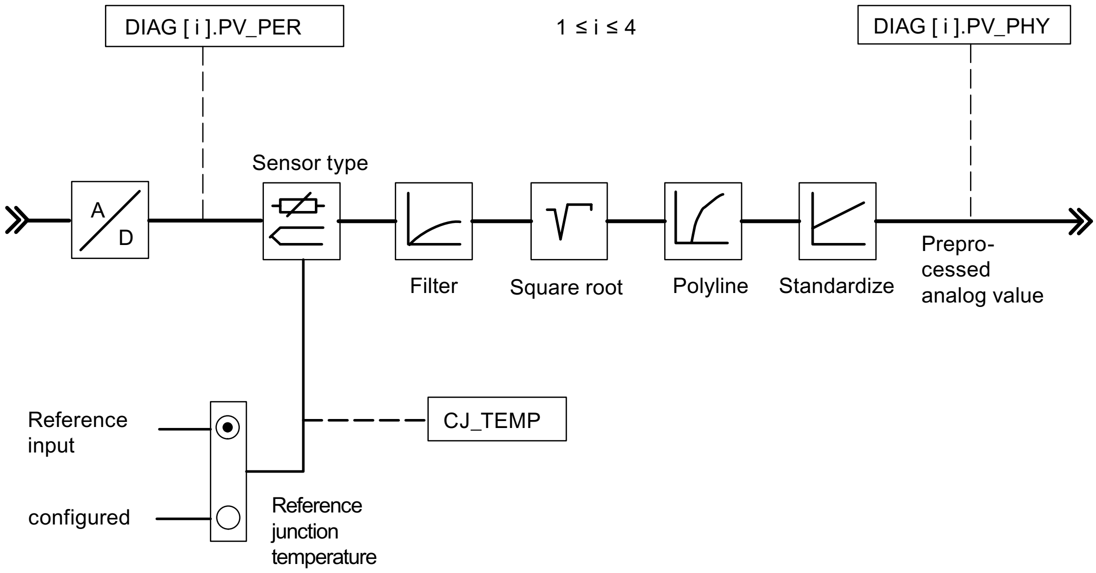


Figure 7-15 Displayed input value

The output parameter, RET_VALU, contains the feedback value RET_VAL of the SFCs RD_REC and WR_REC. With the blocks for PROFINET operation, the RET_VAL includes the 2nd and 3rd bytes of the STATUS parameter of the SFB RDREC and WRREC.

The values of RET_VALU are described in the reference manual /2/.

See also

Instance DB of the READ_355 FB (Page 11-26)

7.6 The CH_DIAG function block

Use

The CH_DIAG FB reads out further channel-specific parameters from the module (to support commissioning).

The CH_DIAG FB does not require an initialization run. It is normally called cyclically.

Creating and Supplying an Instance DB

Before you program the module with the user program, you have to create an instance DB and supply it with important data for each controller channel that you want to use.

1. Use STEP 7 to create the instance DBs for the controller channels as data blocks with an assigned CH_DIAG function block.
2. Enter the module address in the MOD_ADDR parameter at every instance DB.

   The module address of the FM 355 is specified during the configuration of your hardware. Take over the start address from HW Config.
3. Enter the channel number of the corresponding controller channel (1, 2, 3, or 4) in the CHANNEL parameter at every instance DB
4. Save the instance DBs.

Call

The CH_DIAG FB has to be called in the same OB as all the other FBs that access the same FM 355.

Displayed values

The following values are displayed:

- The parameter SP_R is only relevant at ratio or blending controllers. It shows the ratio factor specified via the setpoint value input (refer to the following figure).
- The parameter PV_R is only relevant at a blending controller. It displays the effective actual value (process value) and is calculated as follows: PV_R = (PV - Offset) / PV_D (refer to the following figure). Offset is the parameter that can be configured via the "Multiply" command button.
- DIF_I is the input value of the D-action components of the PID-action controller, not only at ratio or blending controllers (refer to the following figure).

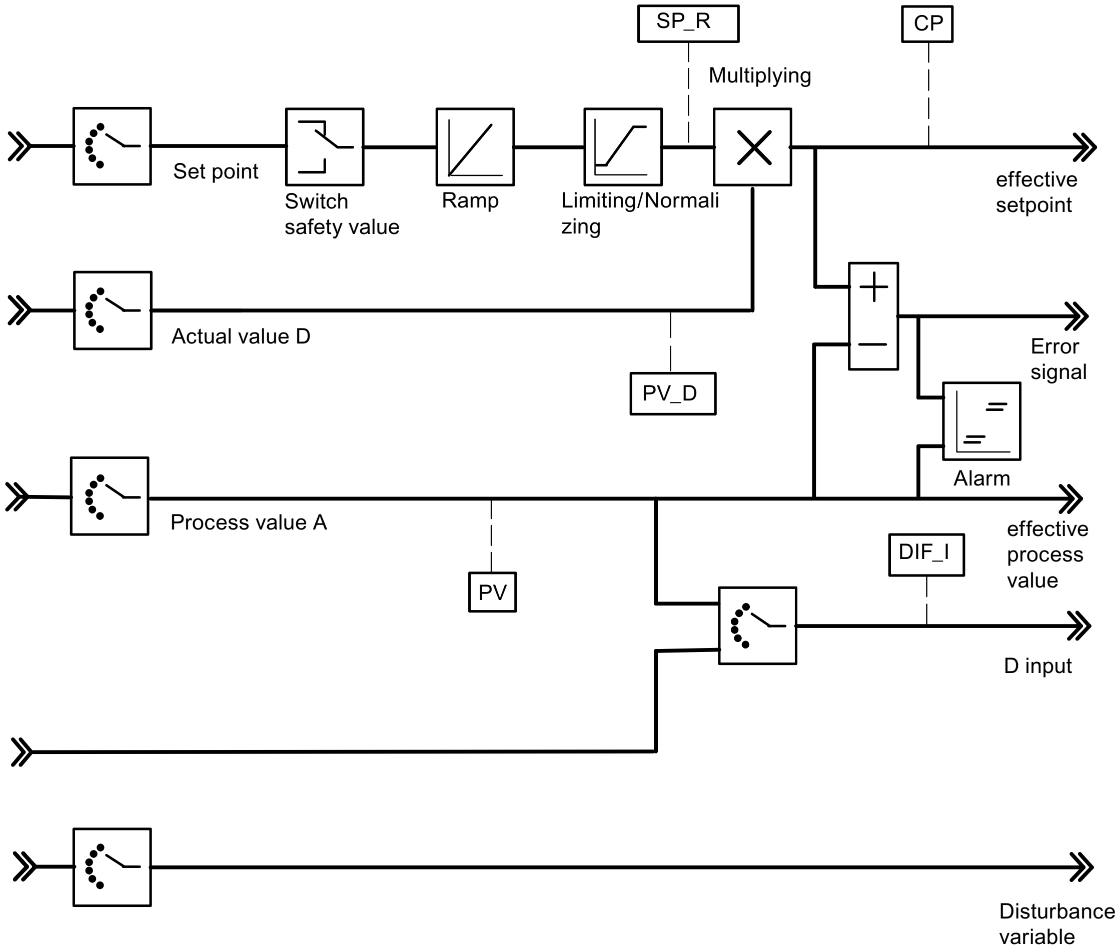


Figure 7-16 Displayed diagnostic values of the negative deviation

- LMN_P is the P part of the PID controller (see following figure)
- LMN_I is the I part of the PID controller (see following figure)
- LMN_D is the D part of the PID controller (see following figure)

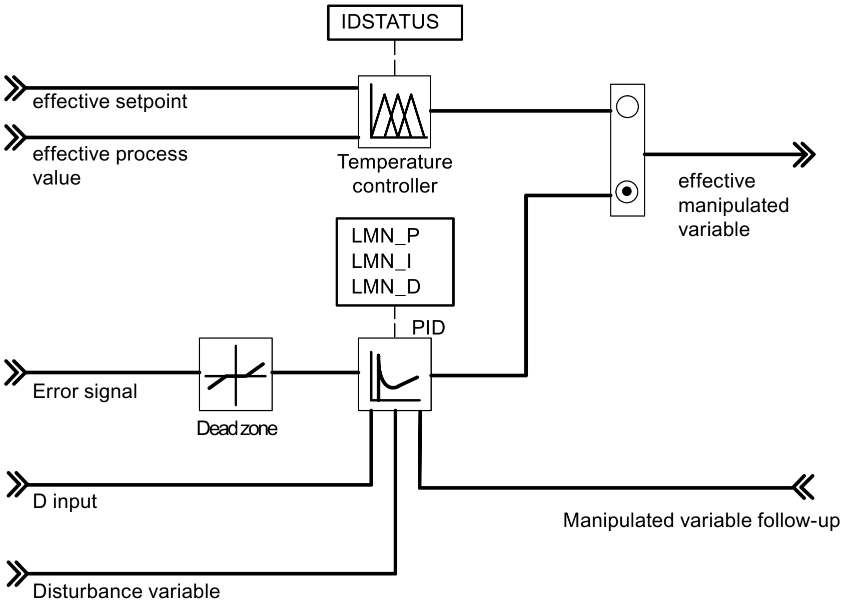


Figure 7-17 Displayed values of the control algorithm

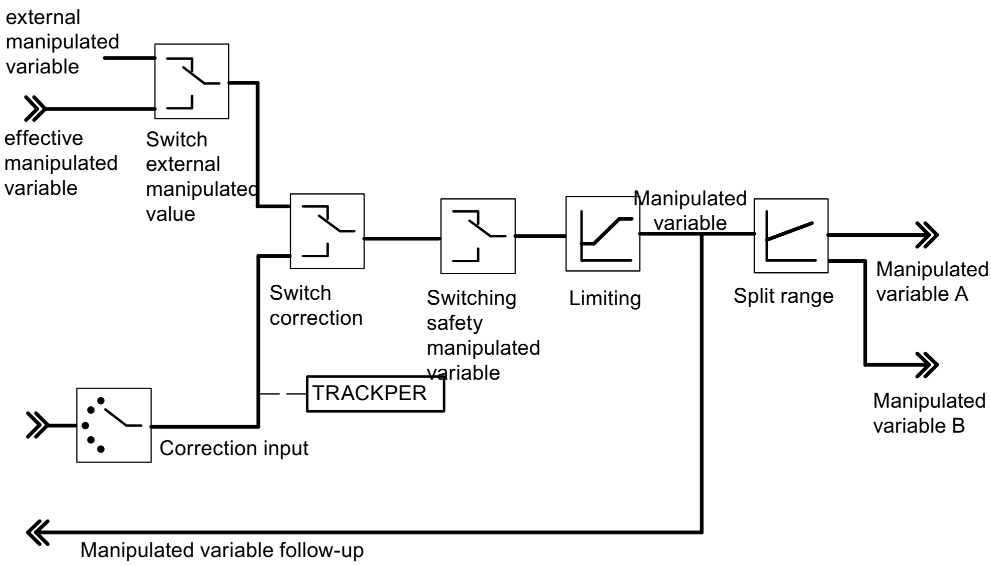


Figure 7-18 Displayed values of the continuous-action controller or step controller

The output parameter, RET_VALU, contains the feedback value RET_VAL of the SFCs RD_REC and WR_REC. With the blocks for PROFINET operation, the RET_VAL includes the 2nd and 3rd bytes of the STATUS parameter of the SFB RDREC and WRREC.

The values of RET_VALU are described in the reference manual /2/.

See also

Parameter optimization with temperature controllers (Page 3-41)

Introduction (Page 7-20)

Instance DB of the CH_DIAG FB (Page 11-28)

7.7 The PID_PAR function block

Use

The PID_PAR FB is used for online changing of further parameters that cannot be specified via the PID_FM FB.

The PID_PAR FB does not require an initialization run. To this purpose it has to be called with the COM_RST = TRUE parameter before it writes data records to the FM 355. Otherwise calling the FB generates a parameter configuration error on the module. You can also read out these parameter assignment errors by using the PLC > Parameter Assignment Error menu of the parameter configuration interface.

In order to save run time the PID_PAR FB should not be called cyclically but only when parameters are to be changed. COM_RST must then be FALSE.

Creating and Supplying an Instance DB

Before you program the module with the user program, you have to create an instance DB and supply it with important data for each controller channel that you want to use.

1. Use STEP 7 to create the instance DBs for the controller channels as data blocks with an assigned PID_PAR function block.
2. Enter the module address in the MOD_ADDR parameter at every instance DB.

   The module address of the FM 355 is specified during the configuration of your hardware. Take over the start address from HW Config.
3. Enter the channel number of the corresponding controller channel (1, 2, 3, or 4) in the CHANNEL parameter at every instance DB
4. Save the instance DBs.

Call

The PID_PAR FB has to be called in the same OB as all the other FBs that access the same FM 355.

Changing Parameter Values

With the PID_PAR FB you can change one each of the REAL parameters listed in the table below and one each of the INT parameters during each call.

Note

With PROFIBUS DP operation, with FB 39 from the "FM 355, 455 PID Control" library there is the restriction that only REAL values with INDEX_R = 30...48 can be transferred simultaneously with an INTEGER value.

The assignment of the specified value to the parameter is carried out via the index numbers contained in the table that you specify at the parameter INDEX_R or INDEX_I in the instance DB of the PID_PAR FB.

If the input COM_RST = TRUE, the FB reads the parameters from the system data are stores them in static variables. The parameters to be changed are overwritten there and the complete data record then transferred to the FM. Since the FB thus has its own data management for the parameters in its static variables, further parameters can also be changed. To this purpose you have to call up the same instance DB several times consecutively with COM_RST = FALSE and with different index numbers.

The parameter COM_RST is an input parameter that is not reset by the FB PID_PAR FB.

The output parameter, RET_VALU, contains the feedback value RET_VAL of the SFCs RD_REC and WR_REC. With the blocks for PROFINET operation, the RET_VAL includes the 2nd and 3rd bytes of the STATUS parameter of the SFB RDREC and WRREC.

The values of RET_VALU are described in the reference manual /2/.

If the FM 355 is used in distributed I/Os, it may take a few call cycles until the parameters have been transferred to the FM 355. The parameter BUSY has the value TRUE until the transfer has been completed. You should therefore repeatedly call the FB PID_PAR when changing parameters until BUSY = FALSE and RET_VALU = 0.

Note

Please note that parameters that you have changed using the PID_PAR FB are overwritten by the parameters from the system data during the start-up.

Example

During operation you want to change the ramp-up time for the reference variable as well as use different analog input values as the actual value depending on the process state.

- Call the PID_PAR FB with COM_RST = TRUE in the start-up of the CPU.
- In order to configure the ramp-up time for the reference variable to 10.0, call the PID_PAR FB during operation with INDEX_R = 30, VALUE_R = 10.0 and INDEX_I = 0.
- If you want to configure the analog input value 4 of the module as the actual value, during runtime call the FB PID_PAR with INDEX_R = 0, INDEX_I = 50 and VALUE_I = 4.

Changeable Parameters

Table 7-1 List of the REAL and INT parameters that can be changed with the PID_PAR FB

Data type	Description	Index number
–	No parameter selected	0
REAL	Filter time constant for analog input	1
REAL	End of measurement (100%)	2
REAL	Beginning of measurement (0%)	3
REAL	Polygon, Interpolation value 1 input side	4
REAL	Polygon, Interpolation value 2 input side	5
REAL	Polygon, Interpolation value 3 input side	6
REAL	Polygon, Interpolation value 4 input side	7
REAL	Polygon, Interpolation value 5 input side	8
REAL	Polygon, Interpolation value 6 input side	9
REAL	Polygon, Interpolation value 7 input side	10
REAL	Polygon, Interpolation value 8 input side	11
REAL	Polygon, Interpolation value 9 input side	12
REAL	Polygon, Interpolation value 10 input side	13
REAL	Polygon, Interpolation value 11 input side	14
REAL	Polygon, Interpolation value 12 input side	15
REAL	Polygon, Interpolation value 13 input side	16
REAL	Polygon, Interpolation value 1 output side	17
REAL	Polygon, Interpolation value 2 output side	18
REAL	Polygon, Interpolation value 3 output side	19
REAL	Polygon, Interpolation value 4 output side	20
REAL	Polygon, Interpolation value 5 output side	21
REAL	Polygon, Interpolation value 6 output side	22
REAL	Polygon, Interpolation value 7 output side	23
REAL	Polygon, Interpolation value 8 output side	24
REAL	Polygon, Interpolation value 9 output side	25
REAL	Polygon, Interpolation value 10 output side	26
REAL	Polygon, Interpolation value 11 output side	27
REAL	Polygon, Interpolation value 12 output side	28

Data type	Description	Index number
REAL	Polygon, Interpolation value 13 output side	29
REAL	Ramp-up time for reference variable	30
REAL	Safety reference variable or safety reference variable response	31
REAL	Offset for setpoint value linkage (ratio/blending controller)	32
REAL	Factor for actual value B (three-component controller)	33
REAL	Factor for actual value C (three-component controller)	34
REAL	Offset for actual value linkage (three-component controller)	35
REAL	Factor for disturbance variable linkage	36
REAL	Operating point	37
REAL	Aggressivity at fuzzy controller	38
REAL	Vertices for split-range function: Start of range input signal A	39
REAL	Vertices for split-range function: End of range input signal A	40
REAL	Vertices for split-range function: Start of range output signal A	41
REAL	Vertices for split-range function: End of range output signal A	42
REAL	Vertices for split-range function: Start of range input signal B	43
REAL	Vertices for split-range function: End of range input signal B	44
REAL	Vertices for split-range function: Start of range output signal B	45
REAL	Vertices for split-range function: End of range output signal B	46
REAL	Minimum pulse time	47
REAL	Minimum break time	48
INT	Selection of the reference variable SP or SP_RE for the controller 0: Setpoint value SP_RE from function block 1 to 4: Analog input value 1 to 4 17 to 20: Manipulated variable (LMN) of Controller 1 to 4	49
INT	Selection of the main controlled variable actual value A for the controller 0: Actual value A = 0.0 1 to 4: Analog input value 1 to 4	50
INT	Selection of the auxiliary controlled variable actual value B for the controller 0: Actual value B = 0.0 1 to 4: Analog input value 1 to 4	51
INT	Selection of the auxiliary controlled variable actual value C for the controller 0: Actual value C = 0.0 1 to 4: Analog input value 1 to 4	52
INT	Selection of the auxiliary controlled variable actual value D for the controller 0: Actual value D = 0.0 1 to 4: Analog input value 1 to 4 17 to 20: Manipulated variable (LMN) of Controller 1 to 4	53
INT	Selection of the disturbance variable DISV for the controller 0: Disturbance variable = 0.0 1 to 4: Analog input value 1 to 4	54
INT	Selection of the position tracking TRACK_PER for the controller 0: Position adjustment = 0.0 1 to 4: Analog input value 1 to 4	55

Data type	Description	Index number
INT	Selection of the position tracking LMNR_PER for the controller 0: Position adjustment = 0.0 1 to 4: Analog input value 1 to 4	56
INT	Selection of the signal for changeover to safety value for the manipulated value of the controller 0: Only specification via SAFE_ON parameter of the PID_FM FB 1 to 8: Specification via SAFE_ON parameter of the PID_FM FB ORed with digital input 1 to 8	57
INT	Selection of the signal for changeover to tracking function of the manipulated value of the controller 0: Only specification via LMNTRKON parameter of the PID_FM FB 1 to 8: Specification via LMNTRKON parameter of the PID_FM FB ORed with digital input 1 to 8	58
INT	Selection of the signal for changeover of the manipulated value of the controller to LMN_RE 0: Only specification via LMN_REON parameter of the PID_FM FB 1 to 8: Specification via LMN_REON parameter of the PID_FM FB ORed with digital input 1 to 8	59
INT	Selection of the upper endstop signal of the position feedback 0: Only specification via LMNRHSRE parameter of the PID_FM FB 1 to 8: Specification via LMNRHSRE parameter of the PID_FM FB ORed with digital input 1 to 8	60
INT	Selection of the lower endstop signal of the position feedback 0: Only specification via LMNRLSRE parameter of the PID_FM FB 1 to 8: Specification via LMNRLSRE parameter of the PID_FM FB ORed with digital input 1 to 8	61

Note

The FB 39 PID_PAR from the "FM 355, 455 PID Control" library uses the SFC 54 RD_DPARM. Therefore, you can only use the FB PID_PAR in the CPUs listed in the following table.

Table 7-2 List of the CPUs, in which the PID_PAR FB can be used

CPU	Order No.:
CPU 312IFM	6ES7 312-5AC01-0AB0
CPU 313	6ES7 313-1AD02-0AB0
CPU 314	6ES7 314-1AE03-0AB0
CPU 314IFM	6ES7 314-5AE02-0AB0
CPU 315	6ES7 315-1AF02-0AB0
CPU 315DP	6ES7 315-2AF02-0AB0
CPU 316	6ES7 316-1AG00-0AB0
CPU 614	6ES7 614-1AH02-0AB3
CPU 412-1	6ES7 412-1XF02-0AB0
CPU 412-2	6ES7 412-2XG00-0AB0
CPU 413-1	6ES7 413-1XG02-0AB0
CPU 413-2	6ES7 413-2XG02-0AB0
CPU 414-1	6ES7 414-1XG02-0AB0
CPU 414-2	6ES7 414-2XG02-0AB0
CPU 414-2	6ES7 414-2XJ01-0AB0
CPU 414-3	6ES7 414-3XJ00-0AB0
CPU 414-3H	6ES7 414-3HJ00-0AB0
CPU 416-1	6ES7 416-1XJ02-0AB0
CPU 416-2	6ES7 416-2XK01-0AB0
CPU 416-2	6ES7 416-2XL01-0AB0
CPU 416-3	6ES7 416-3XL00-0AB0
CPU 417-4	6ES7 417-4XL00-0AB0
CPU 417-4H	6ES7 417-4HL00-0AB0
All future CPUs:	

Note

If you are using a new S7 300 CPU with Micro Memory Card without PROFINET connection, instead of:

FB 39 you must use FB 29
FB 40 you must use FB 30
. The descriptions of both file types used are available in the Appendix.

With a CPU with PROFINET connection you should use the same block from the FM_PID "FM 355 PROFINET" library.

See also

Instance DB of the PID_PAR FB (Page 11-31)

7.8 The CJ_T_PAR Function Block

Use

The CJ_T_PAR FB is used for online modification of the configured reference junction temperature. This is necessary if a temperature control system with several FM 355 units with thermocouple inputs is to be operated without a Pt 100 having to be connected to each FM 355.

If, for example, the reference junction temperature is measured with an FM 355 at an extruder control system with more than four heating zones, this can be read out via READ_355 FB at the CJ_TEMP parameter and configured at the other FM 355 units via the CJ_T_PAR FB.

The CJ_T_PAR FB requires an initialization run. To this purpose it has to be called once in the start-up of the CPU using the COM_RST = TRUE parameter.

The CJ_T_PAR FB is normally called cyclically. To this purpose COM_RST should be set to FALSE for run time reasons.

The COM_RST parameter is an input parameter that is not reset by the CJ_T_PAR FB.

Creating and Supplying an Instance DB

Before you program the module with the user program, you have to create an instance DB and supply it with important data.

1. Use STEP 7 to create the instance DB as data blocks with an assigned CJ_T_PAR function block.
2. Enter the module address in the MOD_ADDR parameter at the instance DB.

   The module address of the FM 355 is specified during the configuration of your hardware. Take over the start address from HW Config.
3. Enter the channel number of the corresponding controller channel (1, 2, 3, or 4) in the CHANNEL parameter at the instance DB
4. Save the instance DB.

The reference junction temperature can be specified at the CJ_T parameter.

The output parameter RET_VALU includes the return value RET_VAL of the SFCs 58 and 59. The values of the RET_VALU are described in the /2/ reference manual.

If the FM 355 is used in distributed I/Os, it may take a few call cycles until the parameter has been transferred to the FM 355. The parameter BUSY has the value TRUE until the transfer has been completed. You should therefore repeatedly call the CJ_T_PAR FB when changing parameters until BUSY = FALSE.

Call

The FB CJ_T-PAR must be called in the same OB as all the other FBs that access the same FM 355.

Note

The FB 40 CJ_T_PAR from the "FM 355,455 PID Control" library uses the SFC 54 RD_DPARM. You can therefore only use the CJ_T_PAR FB in the CPUs listed in the previous table:

Note

If you are using a new S7-300 CPU with Micro Memory Card, then insetad of
FB 39 you must use FB 29
and instead of FB 40 you must use FB 30
. The descriptions of both file types used are available in the Appendix.

With a CPU with PROFINET connection you should use the same block from the FM_PID "FM 355 PROFINET" library

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See also

Instance DB of the CJ_T_PAR FB (Page 11-33)

7.9 PROFINET Operation

General

For the PROFINET operation you have to use the blocks from the FM_PID libraries under "FM 355 PROFINET". Their functionalities correspond to the blocks under "FM 355/455 PID Control" and are described in the same way in chapter 7 and 11. The blocks for PROFINET operation use the SFBs 52/53/81 for data transfer on the FM 355.

SFCs for data transfer without PROFINET operation	SFBs for data transfer with PROFINET operation
SFC 58 "WR_REC”	SFB 53 "WRREC”
SFC 59 "RD_REC”	SFB 52 "RDREC”
SFC 54 "RD_DPARM”	SFB 81 "RD_DPAR”
SFC 102 "RD_DPARA”	SFB 81 "RD_DPAR”

In the blocks from "FM 355 PROFINET", the output parameter RET_VALU is formed from the 2nd and 3rd byte of the STATUS parameter of the SFBs.

Switching to PROFINET operation

The blocks are not interface compatible. When replacing proceed as follows:

Tool	Function	Comment
LAD/STL/FDB	File-> Source generation...	To not lose the parameter assignment again, generate the STL sources of the instance DBs.
SIMATIC Manager	Copying	Copy the required blocks from the "FM_PID->FM355 PROFINET" library into the user program. The existing blocks can be overwritten.
LAD/STL/FDB	File-> Compile	Compile STL sources created above.

The following table shows the blocks with their SFCs/SFBs for the data transfer and the corresponding blocks for PROFINET operation.

"FM 355/455 PID Control" blocks for the Centralized configuration and PROFIBUS operation	"FM 355 PROFINET" blocks for the PROFINET operation
FB31 "PID_FM" SFC58 WR_REC; SFC59 RD_REC	FB31 "PID_FM" SFB52 RDREC; SFB53 WRREC
FB32 "FUZ_355" SFC58 WR_REC; SFC59 RD_REC	FB32 "FUZ_355" SFB52 RDREC; SFB53 WRREC
FB34 "FORCE355" SFC58 WR_REC	FB34 "FORCE355" SFB53 WRREC
FB 36 "READ_355" SFC59 RD_REC	FB36 "READ_355" SFB52 RDREC
FB39 "PID_PAR" SFC58 WR_REC; SFC54 RD_DPARM	FB39 "PID_PAR" SFB53 WRREC; SFC81 RD_DPAR
FB 40 "CJ_T_PAR" SFC58 WR_REC; SFC54 RD_DPARM	FB40 "CJ_T_PAR" SFB53 WRREC; SFC81 RD_DPAR
CPUs with Micro Memory Card: FB29 "PID_PAR using SFC102" SFC58 WR_REC; SFC102 RD_DPARA	Use the FB39. Note however the different functions between FB39 und FB29.
CPUs with Micro Memory Card: FB30 "CJ_T_PAR using SFC102" SFC58 WR_REC; SFC102 RD_DPARA	Use the FB40. Note however the different functions between FB40 and FB30.

Commissioning the FM 355 8

Introduction

In this chapter we show you in a few steps how to commission the FM 355.

HW Installation and Wiring

In order to obtain a better overview the commissioning process is divided into several small steps. In this first section you install the FM 355 into your S7-300 and wire the external I/O elements.

Step	What to do	✓
1	**Determining the slot**	
	Slot 4 to 11 in Rack 0	❒
	Slot 4 to 11 in Rack 1	❒
	Slot 4 to 11 in Rack 2	❒
	Slot 4 to 11 in Rack 3	❒
2	**Installing the FM 355**	
	• Switch the CPU to STOP mode.	❒
	• Remove the neighboring module and plug in the bus connector.	❒
	• Hook in the FM 355 onto the rail and screw it tight.	❒
	• Clip on the slot number.	❒
	• Install the shield contact element	❒
3	**Wiring the FM 355**	
	• Analog inputs (left-hand front connector)	❒
	• Digital inputs (right-hand front connector)	❒
	• Analog outputs (only continuous-action controllers, right-hand front connector)	❒
	• Digital outputs (only step controllers, right-hand front connector)	❒
	• Wiring the supply voltage	❒
	24 V supply voltage L+: right-hand front connector Pin 1	❒
	Mass of supply voltage M: right-hand front connector Pin 20	❒
	• Wiring the reference potential of the analog measuring circuit	
	M_{ANA} left-hand front connector Pin 20	
4	**Front connectors**	
	The front connectors have to be latched in.	❒
5	**Shield**	
	Check the shield of the individual cables.	❒
6	**Switching the power supply on**	
	Switch on the 24 V supply for the FM 355.	❒

Setting Up a New Project

If you want to insert the FM 355 into an existing project, go to the next section.

If you do not have a project yet, create a new project under STEP 7 so that configuration with the parameter configuration mask is possible:

Step	What to do	✓
1	Create a new project under STEP 7.	❐
2	Create a new rack.	❐
3	Enter your hardware structure in the rack in HW Config.	❐
4	Select the FM 355 from the module catalog and drag it to the selected slot.	❐
5	Write down the module address that is now displayed. This value is required for when preparing the instance DB.	____
6	Now call the parameter configuration masks for the FM 355 by double-clicking the FM 355 order number.	❐

Now go to the **Parameter Configuration** section.

Inserting an FM 355 into an Existing Project

If you want to insert an FM 355 into a SIMATIC 300 station of an existing project, proceed as follows:

Step	What to do	✓
1	Open the SIMATIC 300 station of your existing project.	❐
2	Select the FM 355 from the module catalog and drag it to the selected slot.	❐
3	Write down the module address that is now displayed. This value is required for when preparing the instance DB.	____
4	Now call the parameter configuration masks for the FM 355 by double-clicking the FM 355 order number.	❐

Parameter Configuration

Configure the module.

Step	What to do	✓
1	Fill out the masks of the basic configuration: • In the interrupt selection specify whether the FM 355 is to trigger interrupts.	❐
2	Click the **Parameters...** button.	❐
3	Fill out the dialog boxes.	❐
4	Save the parameter configuration using the **File > Save** menu item.	❐

Saving Parameter Configuration Data and Transferring Them to the FM 355

After you have completed the parameter configuration, you have to save the data and prepare the system for operation.

Step	What to do	✓
1	Terminate the parameter configuration interface.	❐
2	Save the project via the **File > Save and compile** menu.	❐
3	Switch the CPU to the STOP mode.	❐
4	Transfer the data to the CPU via the **Download to PLC ...** menu. The data are transferred directly to the CPU and to the FM 355.	❐

Creating an Instance DB

An instance DB has to be created for each controller channel so that you can use the functions of the module.

Step	What to do	✓
1	Create the instance DBs for the controller channels as data blocks with an assigned FB 31 PID_FM function block.	❐
2	Enter the module address in the MOD_ADDR parameter at every instance DB. You wrote down the address while configuring the hardware with STEP 7.	❐
3	Enter the channel number for every instance DB in the CHANNEL parameters.	❐

Commissioning the FM 355

You can now optimize and test your controlled system.

Step	What to do	✓
1	Switch the CPU to the RUN mode.	❐
2	Open the parameter configuration interface and measure the motor actuating time: **Test > Measure motor actuating time** (only at step controllers)	❐
3	Call up the controller optimization: **Test > Controller optimization**	❐
4	Carry out the controller optimization steps.	❐
5	Monitoring and controlling the control loop using the loop monitor: **Test > Loop monitor**	❐
6	Monitor the control loop using the curve recorder: **Test > Curve recorder**	❐

Saving the Project

When you have carried out all the tests successfully and the FM 355 configuration is optimized, you have to save the data again.

Step	What to do	✓
1	Save all the data in the parameter configuration interface by using **File > Save**.	❒
2	Terminate the parameter configuration interface.	❒
3	Save the project via the **File > Save** menu.	❒
4	Transfer the data to the CPU in the STOP mode via the **Download to PLC ...** menu.	❒
5	Switch the CPU to the RUN mode.	❒

See also

Installing and Removing the FM 355 (Page 4-3)

Wiring front connectors (Page 5-8)

9 Properties of Digital and Analog Inputs and Outputs

9.1 Properties of the Digital Inputs and Outputs (Step Controllers)

Properties

The digital inputs and outputs of the FM 355 S have the following properties:

- 8 inputs
- 8 outputs
- Output current 0.1 A
- Rated load voltage: 24 V DC
- Suitable for switches, 2- /3-/4-wire proximity switches (BEROs), solenoid valves, DC contactors and indicator lights

Special Feature

When you supply the 24 V DC supply voltage by means of a mechanical contact, the FM outputs carry the "1" signal for approximately 50 µs, depending on the circuit. You need to take this into account if you connect the FM to fast counters.

Wiring and Block Diagrams

The following figure shows the wiring diagram and the block diagram of the digital inputs and outputs of the FM 355 S.

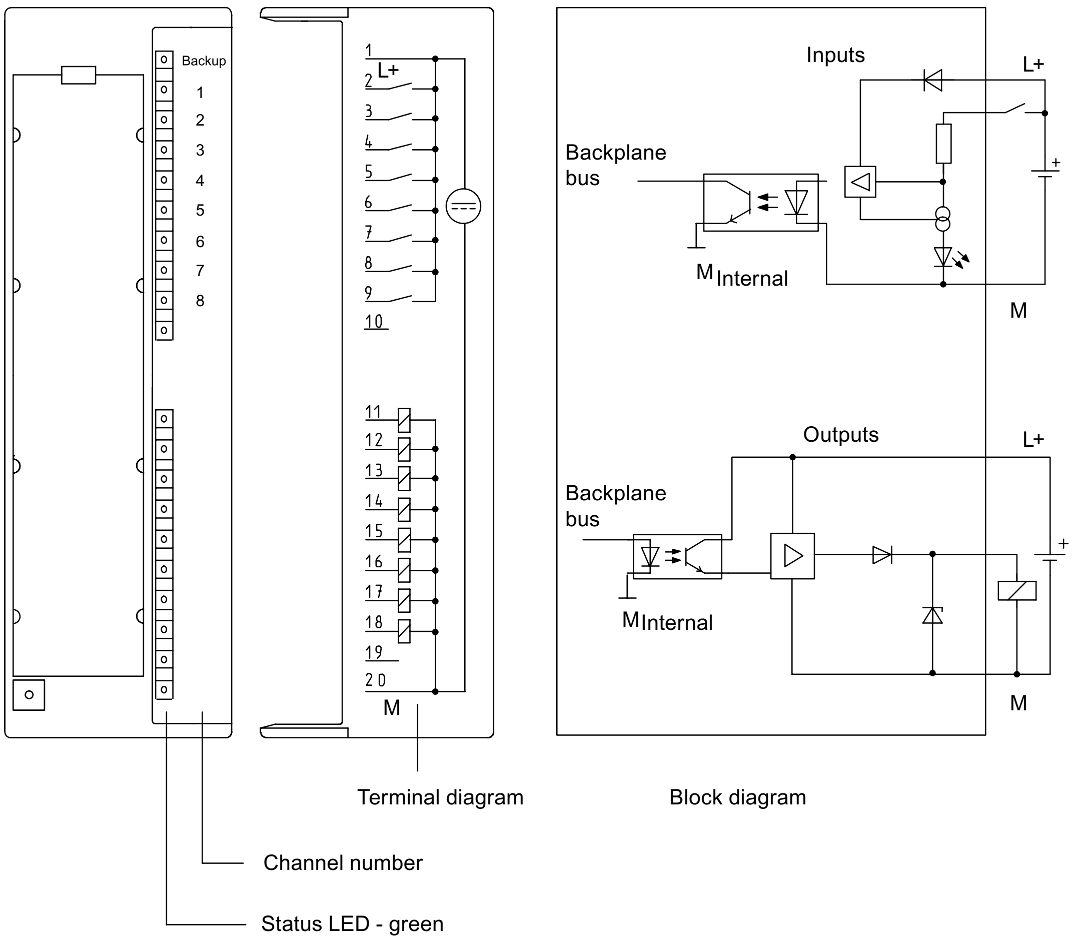


Figure 9-1 Wiring diagram and block diagram of the digital inputs and outputs (step controllers)

The LEDs of the digital outputs are not controlled and do not have any meaning.

See also

Basic Structure of the FM 355 (Page 3-1)

9.2 Properties of the Analog Inputs

Properties

The analog inputs of the FM 355 have the following properties:

- 4 inputs
- Measured value resolution
  - 12 bits
  - 14 bits
- Measuring method selectable per analog input:
  - Voltage
  - Current
  - Resistance
  - Temperature
- Measuring range selection per analog input
- Programmable diagnostics
- Programmable diagnostic interrupt
- Limit monitoring
- Programmable interrupt when limit is exceeded

Current Measurement

At current measurement an external measuring resistor of 50 Ω has to be connected to the analog inputs between M+ and M– .

Reference Input COMP+, COMP-

If you connect a Pt 100 to the analog inputs COMP+ and COMP- to measure the reference junction temperature, you have to supply current to this Pt 100 from the CH3 input (connections IC3+ and IC3–). It is then not possible to connect a Pt 100 to the CH3 input. However, input CH3 can still be used for current or voltage measurement or to connect a thermocouple (refer to the next figure).

Resolution

The integration time results from the selected resolution of the measured value. The higher the resolution precision of the measured value, the longer is the integration time for an analog input channel.

Connection diagram

The following figure shows the connection diagram of the analog inputs of the FM 355.

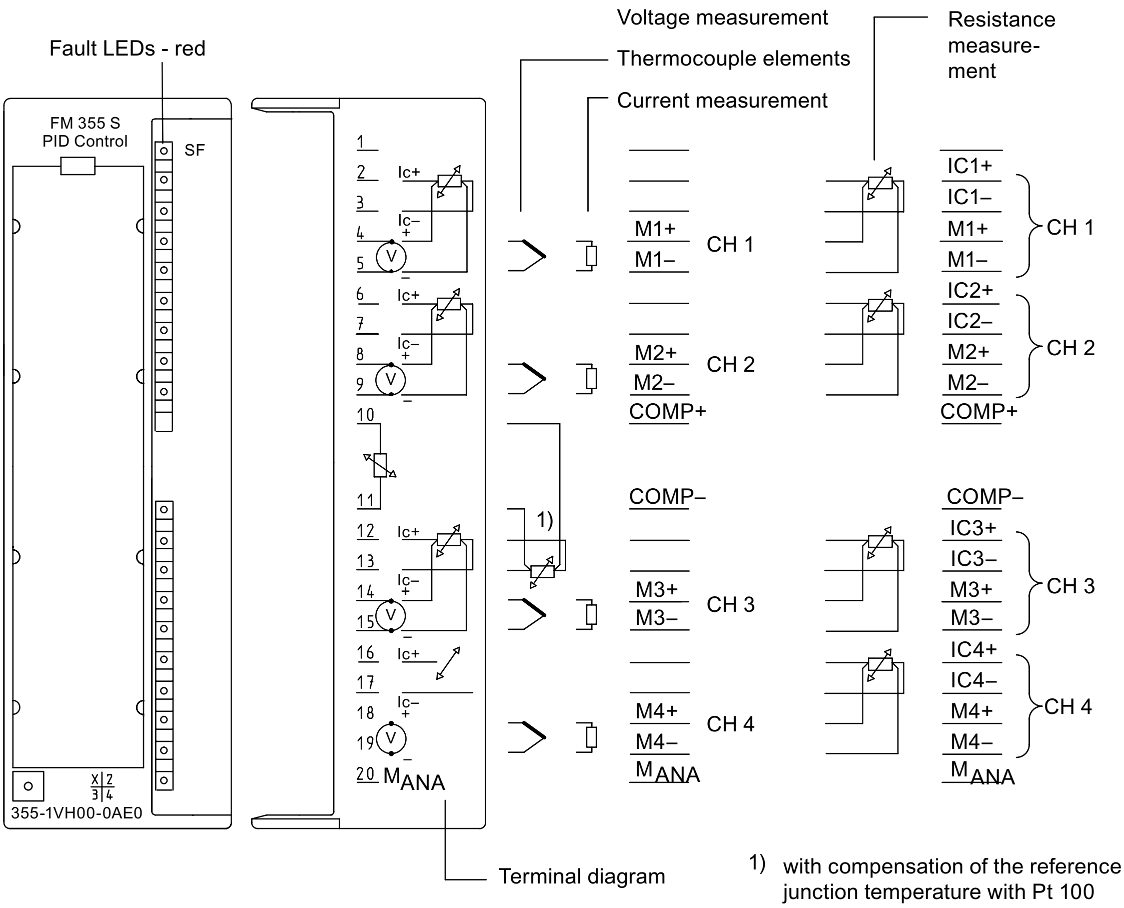


Figure 9-2 Connection diagram of the analog inputs

Block Diagram

The following figure shows the block diagram of the analog inputs. The input impedance is determined by the set measuring range.

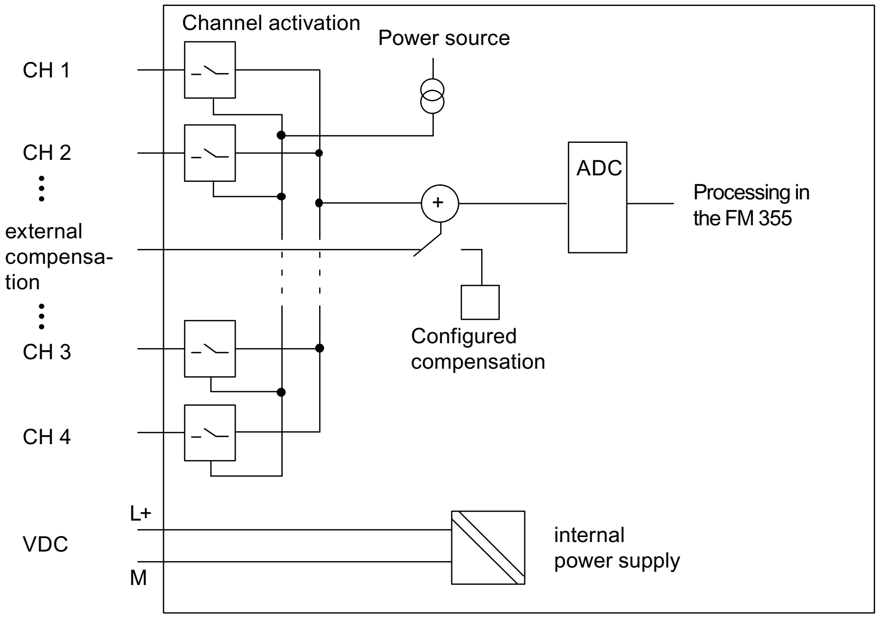


Figure 9-3 Block diagram of the analog inputs

See also

Basic Structure of the FM 355 (Page 3-1)

9.3 Properties of the Analog Outputs (Continuous-Action Controllers)

Properties

The analog outputs of the FM 355 C have the following properties:

- 4 outputs
- The output channels can be programmed as
  - Voltage output
  - Current output
- Resolution 12 bits
- Programmable diagnostics

Note

When you switch the supply voltage (L+) off and on, the output may carry incorrect interim values for the duration of approx. 10 ms.

Connection diagram

The following figure shows the connection diagram of the analog outputs of the FM 355 C.

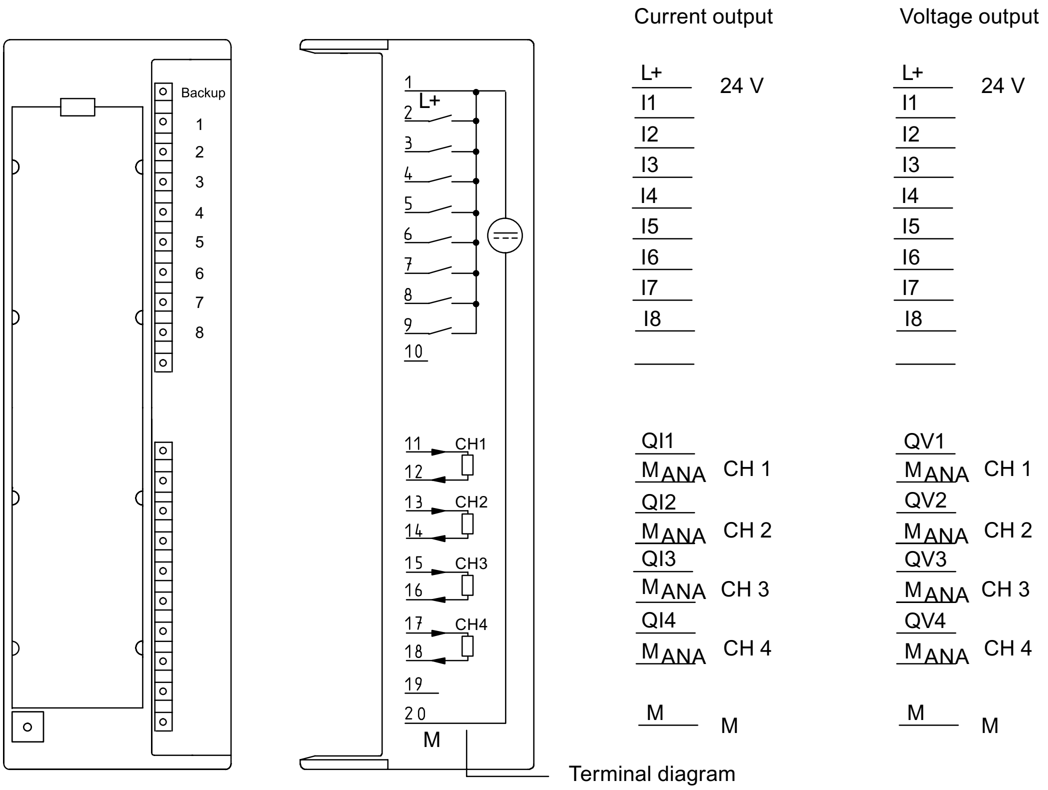


Figure 9-4 Connection diagram of the analog outputs (continuous-action controllers)

Block Diagram

The following figure shows the block diagram of the analog outputs of the FM 355 C.

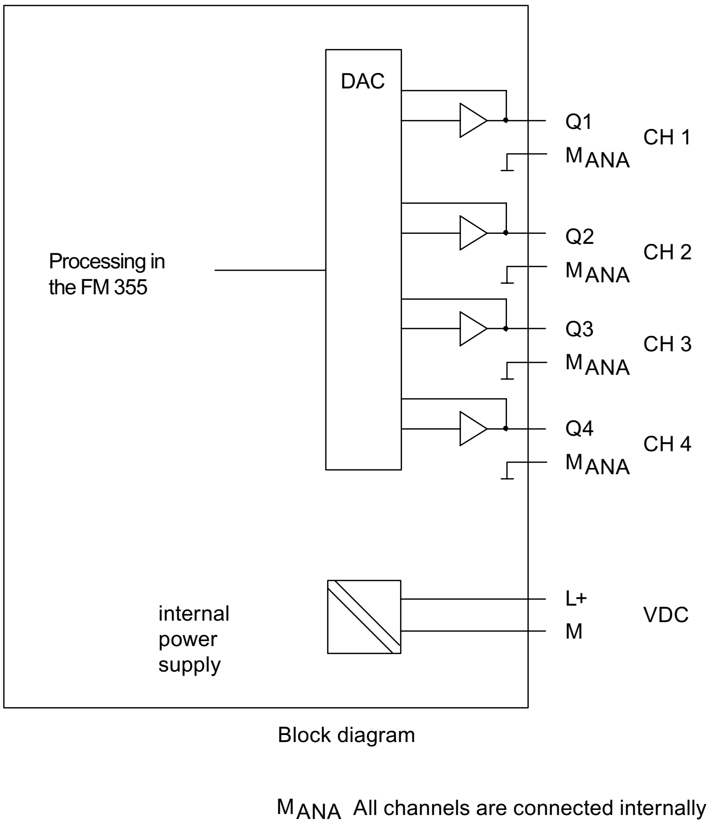


Figure 9-5 Block diagram of the analog outputs (continuous-action controllers)

See also

Basic Structure of the FM 355 (Page 3-1)

Connecting Measuring Transducers and Loads/Actuators 10

10.1 Connecting Measuring Transducers to Analog Inputs

Introduction

Depending on the measuring type used you can connect various measuring transducers to the analog inputs of the FM 355:

- Voltage sensor
- Current sensor as 4-wire measuring transducer and 2-wire measuring transducer
- Resistance

In this section you will find out how to connect the measuring transducers and what to watch for when doing so.

Lines for Analog Signals

You should use shielded and twisted-pair lines for the analog signals. This reduces the effect of interference. You should ground the shield of the analog lines at both ends of the line. Any potential difference between the cable ends may cause an equipotential current on the shield, and thus disturbance on analog signals. If this is the case, you should only ground the shield at one end of the line.

Reference Point M_{ANA}

When operating the FM 355 always interconnect the reference point M_{ANA} of the measuring circuit with terminal M of the CPU. Wire the M_{ANA} terminal to the M terminal of the CPU. Any potential difference between M_{ANA} and the M terminal of the CPU could otherwise corrupt the analog signal.

Abbreviations Used

The abbreviations used in the figures below have the following meaning:

M+:	Measuring line (positive)
M–	Measuring line (negative)
M_{ANA}	Reference potential of the analog measuring circuit
M	Ground terminal
L+	Power supply 24 V DC
U_{CM}	Potential difference between inputs and the reference potential of measuring circuit M_{ANA}

Connecting measuring sensors to analog inputs

No potential difference $\geq|U_{CM}|$ (common mode voltage) may occur between the measuring lines M- of the input channels and the reference point of measuring circuit M_{ANA}. In order for the permitted value not to be exceeded, you have to carry out different measures depending on the potential connection of the sensor (insulated, non-insulated). The steps you have to take are described in this chapter.

Isolated Measuring Transducers

The isolated measuring transducers are not connected to the local ground potential. They can be operated in electrically isolated mode. Depending on local conditions or interference, potential differences U_{CM} (static or dynamic) can occur between the measuring lines M- of the input channels and the reference point of the measuring circuit M_{ANA}.

Note

In order to ensure that the permissible value (U_{CM}) is not exceeded you must connect M- to M_{ANA}.

You must also establish a connection from M- to M_{ANA} when resistance-type sensors are connected. This also applies to inputs which are programmed accordingly, but remain unused.

The following figure shows the connection in principle of insulated measuring transducers to an FM 355.

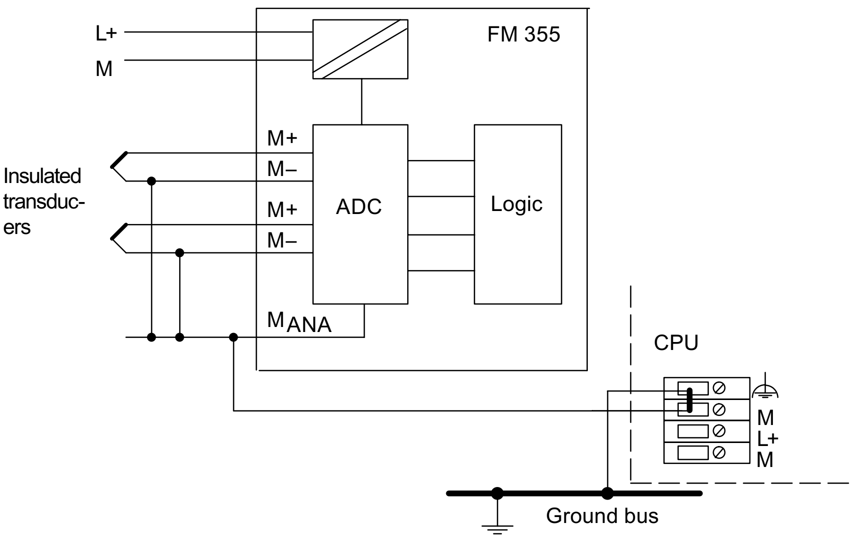


Figure 10-1 Block diagram for the connection of electrically isolated measuring transducers

Non-Isolated Measuring Transducers

The non-isolated measuring transducers are connected to the local ground potential. You must connect M_{ANA} to the ground potential. Local conditions or disturbance may cause potential differences CMV (static or dynamic) between locally distributed measuring points.

If the permissible value for U_{CM} is exceeded, interconnect the measuring points by means of equipotential conductors.

The CPU must be operated ground-coupled. This means that you must provide a jumper between ⏚ and M at the CPU.

The following figure shows the connection in principle of non-isolated measuring transducers to an FM 355.

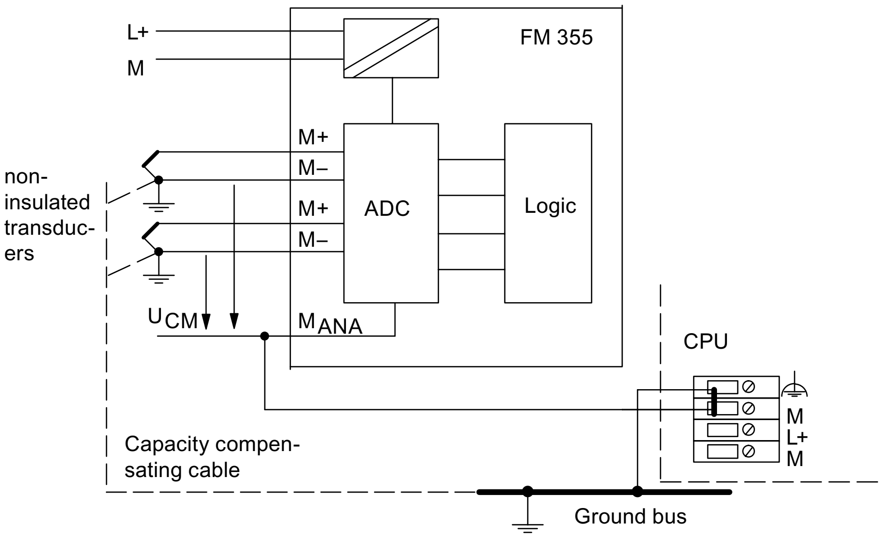


Figure 10-2 Block diagram of the connection of non-insulated measuring transducers

10.2 Use of Thermocouples

Introduction

This section describes the design of thermocouples and the points to be observed when connecting thermocouples.

Thermocouple Structure

A thermocouple comprises

- The thermocouple (detecting elements) and
- The mounting and connection parts required in each case.

The thermocouple consists of two wires made of different metals, or of metal alloys soldered or welded together at their ends. The different thermocouple types, for example, B, J or K, are derived from diverse material compositions. The measuring principle of all thermocouples is the same, irrespective of their type.

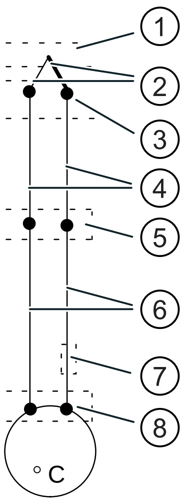


Figure 10-3 Thermocouple structure

①	Measuring point
②	Thermocouple with plus and minus thermo-shanks
③	Connection point
④	Equalizing lead
⑤	Reference junction
⑥	Supply line
⑦	Trimming resistor
⑧	Measuring point of the thermoelectric voltage

Operating Principle of Thermocouples

Any temperature difference between the measuring point and the free ends of the thermocouple induces a thermoelectric voltage which is tapped at the terminating ends.

The thermoelectric voltage induced on the thermocouple is a function of the temperature difference between the measuring point and the free ends, and is also determined by the material factor. Thermocouples always sense a temperature difference. It is therefore essential to hold the free ends at the known temperature of a reference junction, in order to be able to determine the temperature at the measuring junction.

If this is not possible, the reference junction temperature has to be detected and equalized via the additional input with a Pt 100.

Extension to a Reference Junction

The thermocouples can be extended from their connecting point by means of equalizing lines to a point with a temperature which remains constant as far as possible (reference junction).

These compensating wires are made of the same materials as the thermocouple wires. The incoming lines are made of copper. Ensure that the polarity of the equalizing lines is not reversed since large measuring errors will otherwise arise.

Compensation of the Reference Junction Temperature

The influence of temperature fluctuations at the reference junction can be compensated by measuring the reference junction temperature outside the module.

Measuring of the reference junction temperature

The influence of the temperature on the reference junction of a thermocouple (for example the terminal box) can be equalized by measuring the reference junction temperature with a Pt 100.

If the actual reference temperature differs from the comparison temperature, the temperature-dependent resistance changes. A positive or negative compensation voltage occurs that is added to the thermo-electromotive force.

Please note:

- The power supply of Channel 3 must be used to supply the constant current for the Pt 100.
- Channel 3 can then not be used for Pt 100 measurement.

Use of Thermocouples

The following points must be observed when connecting thermocouples:

Depending on where the reference junction is required, either configured or external compensation can be used.

In case of configured compensation a configurable reference junction temperature of the module is used for comparison.

In the case of external compensation the temperature of the reference junction of the thermocouples is taken into consideration by means of a Pt 100.

This Pt 100 is connected to Connections 10 and 11 at the left-hand front connector of the module, whereby the Pt 100 must be applied to the reference junction of the thermocouples. Its power supply must be taken from Channel 3 (Connections 12 and 13 of the left-hand front connector).

The following restrictions apply:

- External compensation with connection of the Pt 100 to Connections 10 and 11 of the module can only be carried out at **one** thermocouple type. This means that all channels operating with external compensation must use the same type.

Abbreviations Used

The abbreviations used in the figures below have the following meaning:

M+:	Measuring line (positive)
M–	Measuring line (negative)
COMP+:	Compensating terminal (positive)
COMP–	Compensating terminal (negative)
M	Ground terminal
L+	Power supply 24 V DC

Connection Alternatives for Thermocouples

The following figures show the various possibilities of connecting thermocouples to external and configured compensation.

In addition to the information below the information contained in the section "Connecting Measuring Transducers to Analog Inputs" applies.

In the figures below the required connecting lines between the M-connection of the CPU, M-, M_{ANA} and the potential to ground which result from the potential connection of the FM 355 to the sensor (insulated, non-insulated) are not shown. This means that you must continue to observe and implement the information given in the section "Connecting Measuring Transducers to Analog Inputs".

Thermocouples with External Compensation of the Reference Junction

If all the thermocouples which are connected to the inputs of the FM 355 have the same reference junction, carry out compensation as shown in the following figure. The thermocouples which use a reference junction must be of the same type.

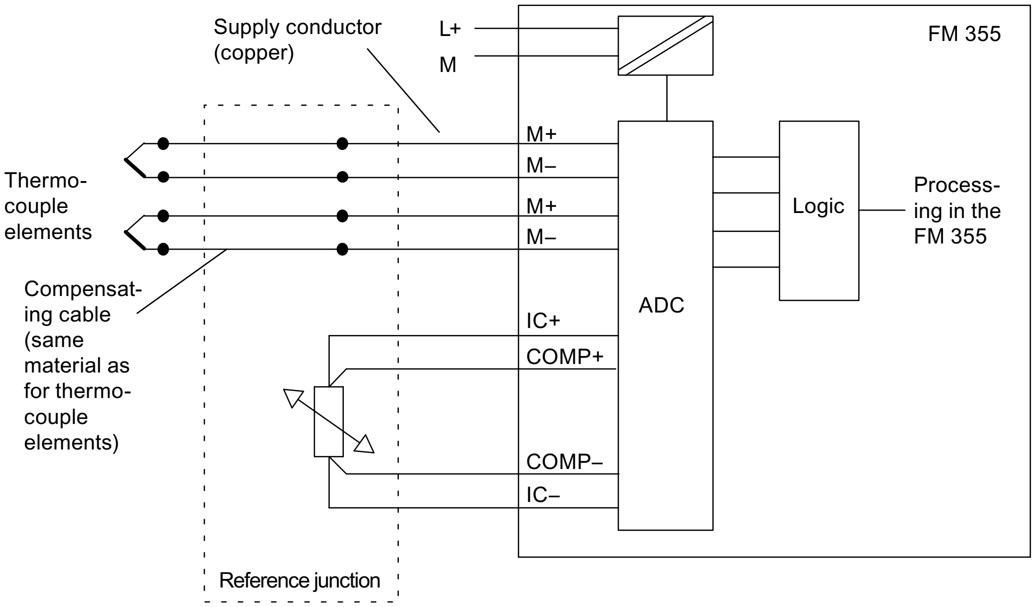


Figure 10-4 Block diagram for connecting thermocouples with external compensation

Grounding of thermocouples is shown in the figures in the section "Connecting Measuring Transducers to Analog Inputs".

Thermocouples with Configured Compensation of the Reference Junction

The configured temperature compensation can be used when thermocouples are connected directly or via equalizing lines to the inputs of the module.

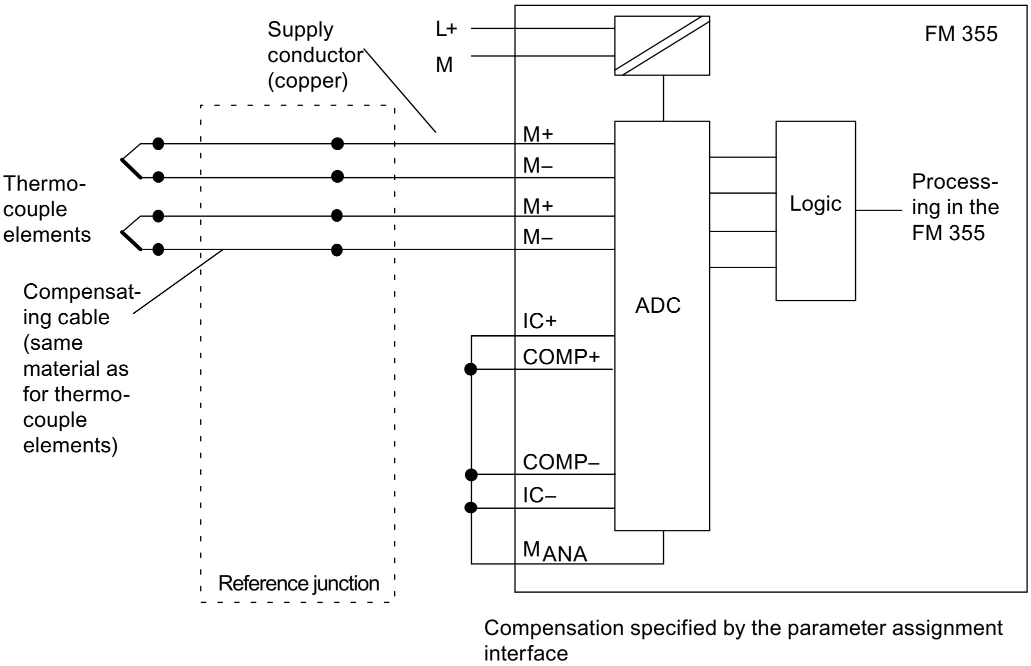


Figure 10-5 Block diagram for connecting thermocouples with configured compensation

Grounding of thermocouples is shown in the figures in the section "Connecting Measuring Transducers to Analog Inputs".

10.3 Connecting Voltage Sensors, Current Sensors and Resistance Thermometers

Introduction

The following figures show how to connect voltage sensors, current sensors and resistance thermometers.

Abbreviations Used

The abbreviations used in the figures below have the following meaning:

I_C+	Constantcurrent line (positive)
I_C–	Constantcurrent line (negative)
M+:	Measuring line (positive)
M–	Measuring line (negative)
M_{ANA}	Reference potential of the analog measuring circuit
M	Ground terminal
L+	Power supply 24 V DC

In addition to the information below the information contained in the section "Connecting Measuring Transducers to Analog Inputs" applies.

In the figures below the required connecting lines between the M-connection of the CPU, M-, M_{ANA} and the potential to ground which result from the potential connection of the FM 355 to the sensor (insulated, non-insulated) are not shown. This means that you must continue to observe and implement the information given in the section "Connecting Measuring Transducers to Analog Inputs".

Connection of Voltage Sensors

The following figure shows the connection of voltage sensors to an FM 355.

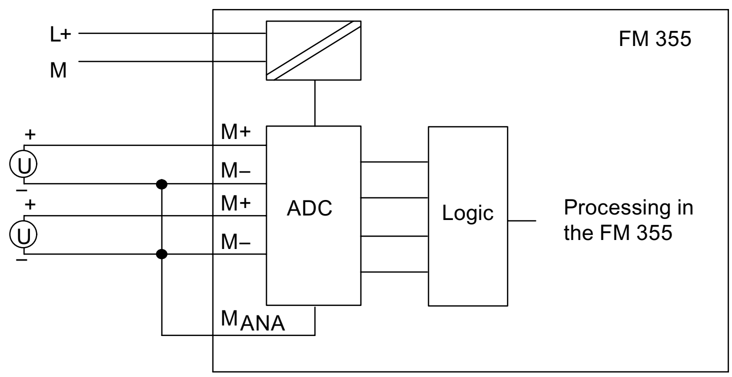


Figure 10-6 Connection of voltage sensors

Connection of Current Sensors As Four-Wire Measuring Transducers

Four-wire measuring transducers have a separate power supply.

The following figure shows the connection of current sensors as 4-wire measuring transducers to an FM 355.

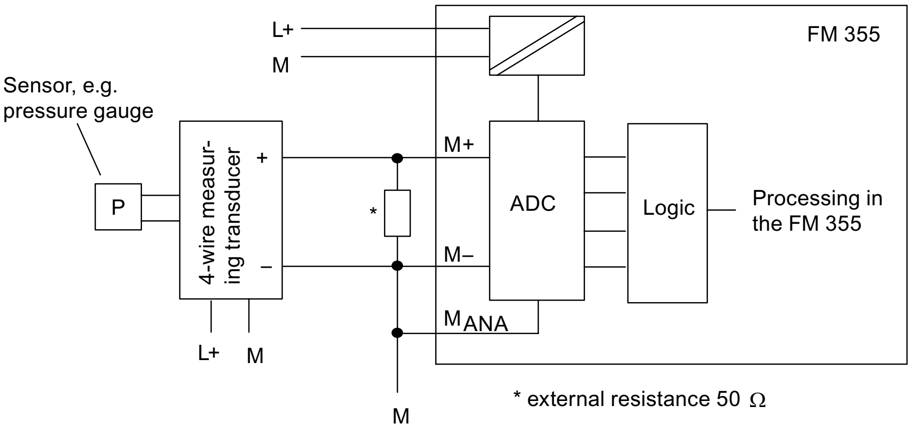


Figure 10-7 Connecting 4-wire measuring transducers

Connection of Current Sensors As Two-Wire Measuring Transducers

The 2-wire measuring transducer converts the fed measured variable into a current.

You have to wire the supply voltage short-circuit-proof to the 2-wire measuring transducer. Provide for a fuse as shown in the following figure.

2-wire measuring transducers must be electrically isolated.

The following figure shows the connection of current sensors as 2-wire measuring transducers.

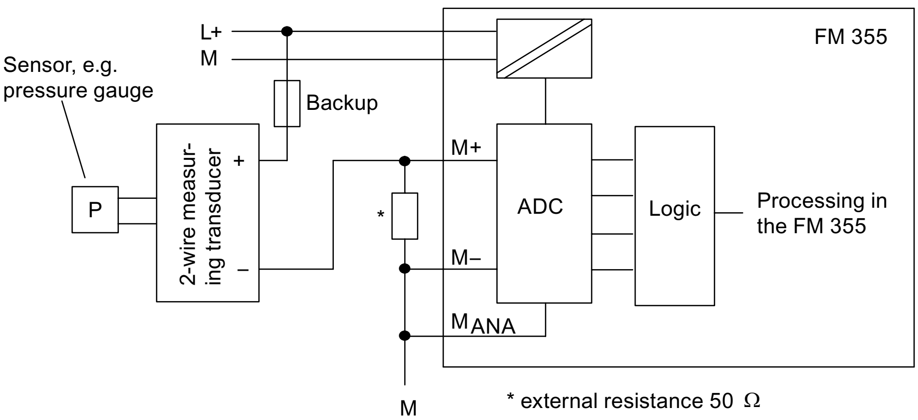


Figure 10-8 Connecting 2-wire measuring transducers

Connection of Resistance Thermometers (For Example, Pt 100) and Resistors

The resistance thermometers/resistors are measured in a four-wire connection. Constant current is fed to the resistance thermometers/resistors by means of the connections I_{C+} and I_{C-}. The voltage arising at the resistance thermometer/resistor is measured at the connection M + and M -. This ensures highly accurate measurement results with the four-conductor connection.

The following figure shows the connection of resistance thermometers to an FM 355.

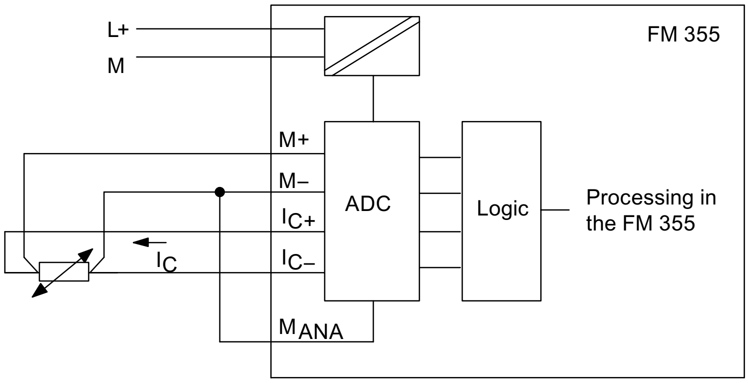


Figure 10-9 Connecting resistance thermometers

With the two/three-conductor connection, you must apply corresponding jumpers to the module between M+ and I_{C+} or M- and I_{C-}. However, you have to expect a loss of accuracy in the measurement results.

10.4 Connecting Loads/Actuators to Analog Outputs

Introduction

With the FM 355 C you can supply the loads / actuators with current or voltage. The figure below illustrates the principle.

Lines for Analog Signals

You should use shielded and twisted-pair lines for the analog signals. This reduces the effect of interference. You should ground the shield of the analog lines at both ends of the line. If there are differences in potential between the ends of the cables, equipotential current may flow across the shield, which could disturb the analog signals. If this is the case, you should only ground the shield at one end of the line.

Reference Point M_{ANA}

When operating the module always interconnect the reference point M_{ANA} of the measuring circuit with terminal M of the CPU. Connect the M_{ANA} terminal to the M terminal of the CPU. A difference in potential between M_{ANA} and the M connection of the CPU might give rise to a corruption of the analog signal.

Abbreviations Used

The abbreviations used in the figure below have the following meaning:

Q	Analog output (current or voltage, depending on the configuration)
M_{ANA}	Reference potential of the analog circuit
R_L:	Load/Actuator
L+	Power supply 24 V DC
M	Ground terminal

Connecting Loads to an Analog Output

Loads at an analog output have to be connected to Q and the reference point of the analog circuit M_{ANA}.

Loads can only be connected to an analog output with a 2-wire connection.

The following figure shows the principle connection of loads to an analog output of an FM 355 C.

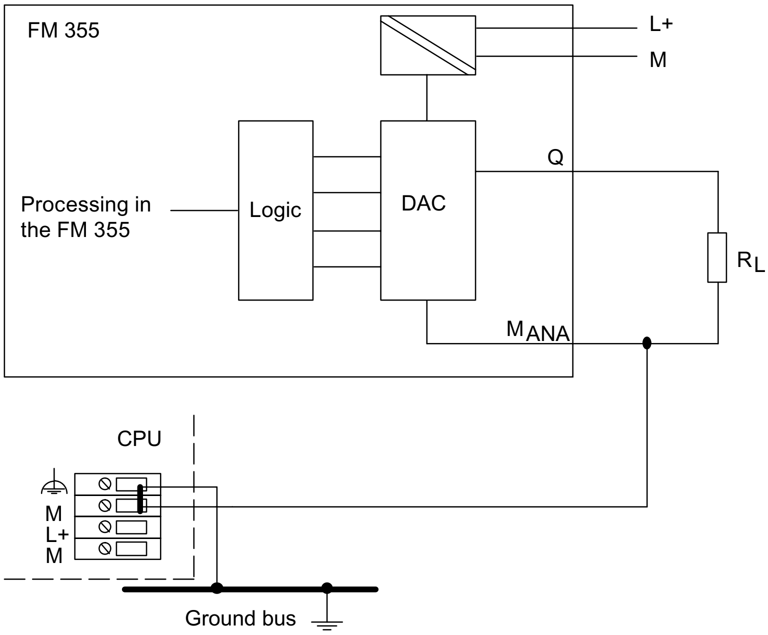


Figure 10-10 Connecting a load to an FM 355 C

10.5 Connecting Loads/Actuators to Digital Outputs

Introduction

Voltage can be supplied to loads/actuators by means of the FM 355 S. The following figure illustrates the principle:

Abbreviations Used

The abbreviations used in the figure below have the following meaning:

Q	Digital output
R_L:	Load/Actuator
L+	Power supply 24 V DC
M	Ground terminal

Connecting Loads/Actuators to a Digital Output

The following figure shows the connection in principle of loads/actuators to a digital output of an FM 355 S.

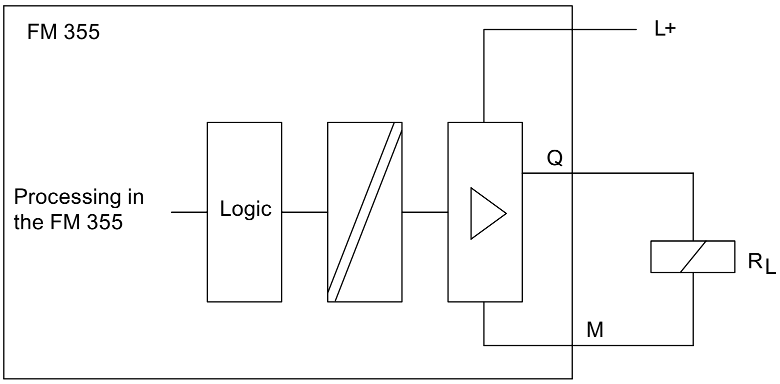


Figure 10-11 Connection of loads/actuators to an FM 355 S

11 Assignment of the Instance DBs

11.1 Instance DB of the PID_FM FB

Introduction

If you want to communicate with the FM 355 from the user program, you require the PID_FM FB. In addition you have to create an instance DB, that is assigned to the FB, for each used controller channel.

Note

All the in/out parameters are set to FALSE after an instance DB has been created.

In order to transfer the parameters from the FM 355 to the instance DB you have to carry out an initialization run at which the in/out parameter COM_RST = TRUE.

The following tables list the parameters of this instance DB:

- Input parameters
- Output parameters
- In/out parameters

Input Parameters

Table 11-1 Input parameters of the instance DB for the PID_FM FB

Add.	Parameter	Data Type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assignment screen form
0.0	MOD_ADDR	INT	FM 355/455 module address		256	The module address that resulted from the configuration with STEP 7 is given at this input.	-
2.0	CHANNEL	INT	Channel Number	1 to 4	1	The number of the controller channel to which the instance DB refers is configured at the "Channel number" input.	-
4.0	PHASE	INT	Phase of PID self tuner	Is not configured	0	The PHASE parameter can be interconnected with the PHASE output parameter of a PID self-tuner (program for self-tuning of controller parameters). The phase state of the PID self tuner can then be displayed in clear text in the loop monitor. This parameter is not relevant for the OP.	-

Output Parameters

Table 11-2 Output parameters of the instance DB for the PID_FM FB

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assign-ment screen form
6.0	RET_VALU	INT	Return value SFC 58/59 SFB 52/53		0	RET_VALU includes the return value RET_VAL of the SFC 58/59. With the block for PROFINET Mode, the RET_VAL includes the 2nd and 3rd bytes from the STATUS parameter of the SFB 52/53. RET_VALU can be evaluated if an error is reported via the QMOD_F (see reference manual /2/).	-
8.0	out_par	WORD	Begin of output parameters	W#16#3130	W#16#3130	The out_par parameter may not be overwritten by the user. It marks the start of the output parameter that is read by the module if READ_VAR = TRUE is set.	-
10.0	SP	REAL	Setpoint	Technical range of values (physical variable)	0.0	The setpoint value that is currently in effect is available at the "Setpoint" output.	-
14.0	PV	REAL	Process variable	Technical range of values (physical variable)	0.0	The effective process variable is output at the "process variable" output.	-
18.0	ER	REAL	Error signal	Technical range of values (physical variable)	0.0	The effective negative deviation is output at the "Negative deviation" output.	-
22.0	DISV	REAL	Disturbance variable	-100.0...100.0 (%)	0.0	The effective disturbance variable is output at the "Disturbance variable" output.	-

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assign-ment screen form
26.0	LMN	REAL	Manipulated value	-100.0...100.0 (%)	0.0	The effective manipulated value is output at the "Manipulated value" output. At a step controller without analog position feedback the unlimited P- + D-action component is output at the LMN parameter.	-
30.0	LMN_A	REAL	Manipulated value A of split range function/repeated manipulated value	-100.0...100.0 (%)	0.0	On the output "Manipulated value A of the split range function / position feedback" in the case of continuous controllers the manipulated value A of the split range function, and with step controllers with analog position feedback, the position feedback is displayed. The LMN_A output can only be used for an approximate display of a respective simulated manipulated variable. In doing so, the start value LMNRSVAL of the simulated position feedback has to be configured accordingly and becomes effective when LMNRS_ON is set.	-
34.0	LMN_B	REAL	Manipulated value B of split range function	-100.0...100.0 (%)	0.0	Manipulated value B of the split-range function is displayed at the output "Manipulated value B of the split-range function§ at a continuous-action controller.	-

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assign-ment screen form
38.0	QH_ALM	BOOL	High limit alarm reached		FALSE	The actual value or the controlled variable is monitored for four limits. Exceeding of the limit H_ALM is signaled at the "Upper limit alarm triggered" output.	-
38.1	QH_WRN	BOOL	High limit warning reached		FALSE	The actual value or the controlled variable is monitored for four limits. Exceeding of the limit H_WRN is signaled at the "Upper limit warning triggered" output.	-
38.2	QL_WRN	BOOL	Lower limit warning reached		FALSE	The actual value or the controlled variable is monitored for four limits. Exceeding of the limit L_WRN is signaled at the "Lower limit warning triggered" output.	-
38.3	QL_ALM	BOOL	Low limit alarm reached		FALSE	The actual value or the controlled variable is monitored for four limits. Exceeding of the limit L_ALM is signaled at the "Lower limit alarm triggered" output.	-
38.4	QLMN_HLM	BOOL	High limit of manipulated value reached		FALSE	The manipulated variable is always limited to an high and a low limit. The "high limit of manipulated value reached" output displays the exceeding of the upper limit. (this does not apply to step-action controllers without analog position feedback).	-

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assign-ment screen form
38.5	QLMN_LLM	BOOL	Low limit of manipulated value reached		FALSE	The manipulated variable is always limited to an high and a low limit. The "low limit of manipulated value reached" output displays the falling short of the low limit. (this does not apply to step-action controllers without analog position feedback).	-
38.6	QPARA_F	BOOL	Parameter assignment error		FALSE	The module checks the validity of the parameters. A parameter configuration error is displayed at the "Parameter configuration error" output. You can also read out these parameter assignment errors by using the **PLC > Parameter Assignment Error** menu of the parameter configuration interface.	-
38.7	QCH_F	BOOL	Channel error		FALSE	The output "Channel error" is set if the controller channel cannot supply any valid results. "Channel error" (e.g. wire break) is also set if QPARA_F = 1 or QMOD_F = 1. If QCH_F = TRUE, then the precise error information in the diagnostic record DS1 of the module is read off.	-
39.0	QUPRLM	BOOL	Limit of positive setpoint inclination reached		FALSE	The setpoint is limited in positive and negative inclination. If the output "Limit of positive setpoint inclination triggered" is set, the positive setpoint inclination is limited.	-

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assign-ment screen form
39.1	QDNRLM	BOOL	Limit of negative setpoint inclination reached		FALSE	The setpoint is limited in positive and negative inclination. If the "negative set value inclination reached" output is set, then the set value inclination is restricted.	-
39.2	QSP_HLM	BOOL	High limit of setpoint reached		FALSE	The setpoint is always limited by an upper and lower limit. The output "Upper limit of setpoint value triggered" indicates that the upper limit has been exceeded.	-
39.3	QSP_LLM	BOOL	Low limit of setpoint reached		FALSE	The setpoint is always limited to a high and a low limit. The "low limit of set value reached" output displays the falling short of the low limit.	-
39.4	QLMNUP	BOOL	Manipulated signal up		FALSE	This is the output "Manipulated value signal up". (For step controllers or pulse controllers only)	-
39.5	QLMNDN	BOOL	Manipulated signal down		FALSE	This is the output "Manipulated value signal down". (For step controllers or pulse controllers only)	-
39.6	QID	BOOL	Identification in work		FALSE	QID = TRUE shows that an identification is running (not that it is switched on). After the end of identification the identification result can be read out via the IDSTATUS parameter of the CH_DIAG FB.	-

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assign-ment screen form
40.0	QSPOPON	BOOL	Setpoint operation on		FALSE	The output "set value operation on" shows if the set value is being operated by the configuration tool. If the bit is set, the value SP_OP is used as the setpoint value.	-
40.1	QLMNSAFE	BOOL	Safety operation		FALSE	If the output "Safety mode" is set, the safety manipulated value is output as the manipulated value.	-
40.2	QLMNOPON	BOOL	Manipulated value operation on		FALSE	The output "manipulated value operation on" shows if the set value is being operated by the configuration tool. If the bit is set, the value LMN_OP is used as the manipulated value.	-
40.3	QLMNTRK	BOOL	Follow-up operation		FALSE	The output "Follow-up mode" indicates whether the manipulated value is tracked via an analog input.	-
40.4	QLMN_RE	BOOL	Manual = 1 Automatic = 0		FALSE	The output "manual = 1; automatic = 0" indicates whether or not the manipulated value is set on the external manipulated value LMN_RE (manual = 1).	-
40.5	QLMNR_HS	BOOL	High limit signal of repeated manipulated value		FALSE	The output "Upper end stop signal of position feedback" indicates whether the control valve is at its upper limit. QLMNR_HS = TRUE means: The control valve is at its upper limit. (For step controllers only)	-

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assign-ment screen form
40.6	QLMNR_LS	BOOL	Low limit signal of repeated manipulated value		FALSE	The output "Lower end stop signal of position feedback" indicates whether the control valve is at its lower limit. QLMNR_LS = TRUE means: The control valve is at its lower limit. (For step controllers only)	-
40.7	QLMNR_ON	BOOL	Repeated manipulated value on		FALSE	The output "position feedback on" shows the set mode "step controller with position feedback" or "step controller without position feedback".	-
41.0	QFUZZY	BOOL	PID algorithm = 0 fuzzy = 1		FALSE	If the output QFUZZY = 1 is set, the controller operates with the fuzzy algorithm.	-
41.1	QSPLEPV	BOOL	Fuzzy display: Setpoint < process variable		FALSE	The output "Display of FUZZY controller: set value < actual value" is set when the fuzzy controller is switched on, if the set value is less than the effective actual value.	-
41.2	QSPR	BOOL	Split-range operation		FALSE	If the output "Split-range operation" is set, the continuous controller is operating in split-range mode.	-

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assign-ment screen form
41.4	QMAN_FC	BOOL	Manual mode or anti-reset-windup by follower controller		FALSE	The output "QMAN_FC" is set in the following two cases: the slave controller is in manual mode and the main controller is followed up to the actual value of the slave controller. The I-action component of the master controller is stopped because the setpoint value or manipulated variable of the secondary controller is limited or because the secondary controller is in manual mode.	-
41.7	QPARABUB	BOOL	Internal value		FALSE	This parameter is set by the FM when operating parameters are changed via the OP. If READ_VAR = TRUE and if this display is set by the FM, the PID_FM FB reads the parameters SP_OP_ON, LMNOP_ON, SP_OP and LMN_OP out of the FM and saves them in the instance DB. The FB thus takes over the operating state of the FM. After the reading process the parameter is set to FALSE.	-

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assign-ment screen form
42.0	QMOD_F	BOOL	Module error		FALSE	The function block checks correct reading and writing of a data record. In the case of detected errors the output "Module error" is set. The error cause can be: An incorrect module address at the parameter MOD_ADDR, an incorrect channel number at the parameter CHANNEL or a defective module.	-

In/Out Parameters

Table 11-3 I/O parameters of the instance DB for the PID_FM FB

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In para-meter configu-ration mask
44.0	COM_RST	BOOL	Read control parameters from FM 355/455		FALSE	If the parameter COM_RST = TRUE is set, the PID_FM FB carries out an initialization run. In the process the control parameters (all the parameters after cont_par) are read from the FM and stored in the instance DB. In addition, the validity of the parameters MOD_ADDR and CHANNEL is checked. After the initialization run the parameter is set to FALSE.	-

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In parameter configuration mask
44.1	LOAD_OP	BOOL	Load operator parameter to FM 355/455		FALSE	If the through parameter "Load operator parameter to FM 355/455" is set, the operating parameters are loaded into the module and the through parameter is reset.	-
44.2	READ_VAR	BOOL	Read variables from FM 355/455		FALSE	If the through parameter "Read variables from FM 355/455" is set, the output parameters are read from the module and the through parameter is reset.	-
44.3	LOAD_PAR	BOOL	Load control parameter to FM 355/455		FALSE	If the through parameter "Load control parameter to FM 355/455" is set, the control parameters are loaded into the module and the through parameter is reset.	-
46.0	op_par	WORD	Begin of operating parameters	W#16#3130	W#16#3130[2)]	The op_par parameter may not be overwritten by the user. It identifies the start of the operator parameters that are transferred to the module, if LOAD_OP = TRUE is set. The end of the operating parameter is shown by cont_par.	-
48.0	SP_RE	REAL	External setpoint	Technical range of values (physical variable)	0.0	An external setpoint is connected to the controller at the "external setpoint" input.	-
52.0	LMN_RE	REAL	External manipulated value	-100.0...100.0 (%)	0.0	An external manipulated value is interconnected to the controller at the input "External manipulated value".	-
56.0	SP_OP_ON[1)]	BOOL	Setpoint operation on		FALSE	The configuration tool has access to the through parameter "Setpoint operation on". If the bit is set, the value SP_OP is used as the setpoint value.	-

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In parameter configuration mask
56.1	SAFE_ON	BOOL	Safety position on		FALSE	If the "assume safety position" input is set, a security value is adopted as the manipulated value. Note: The actuating signal processing via LMNDN_OP, LMNUP_OP and LMNSOPON with step controllers has greater priority than the safety manipulated variable.	-
56.2	LMNOP_ON 1)	BOOL	Manipulated value operation on		FALSE	The configuration tool has access to the through parameter "Manipulated variable operation on". If the bit is set, the value LMN_OP is used as the manipulated value.	-
56.3	LMNTRKON	BOOL	Match (LMN from analog input)		FALSE	If the input "Track (LMN via analog input)" is set, the manipulated value is tracked to an analog input. (this does not apply to step-action controllers without analog position feedback).	-
56.4	LMN_REON	BOOL	External manipulated value on		FALSE	If the input "Switch external manipulated value on" is set, the external manipulated value LMN_RE is used as the manipulated value.	-
56.5	LMNRHSRE	BOOL	High limit signal of repeated manipulated value		FALSE	The signal "Manipulated valve on high stop" is switched on the "high stop signal of the position feedback" input. LMNRHSRE = TRUE means: The control valve is at its upper limit. (For step controllers only)	-

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In parameter configuration mask
56.6	LMNRLSRE	BOOL	Low limit signal of repeated manipulated value		FALSE	The signal "Manipulated valve on low stop" is switched on the "low stop signal of the position feedback" input. LMNRLSRE = TRUE means: The control valve is at its lower limit. (For step controllers only)	-
56.7	LMNSOPON 1)	BOOL	Manipulated signal operation on		FALSE	If the bit on the input "Manipulated value signal operation on" is set, the signals LMNUP_OP and LMNDN_OP are adopted as the manipulated value signals. (For step controllers only)	-
57.0	LMNUP_OP 1)	BOOL	Manipulated signal up operation		FALSE	If LMNSOPON is set, the value at the input "Manipulated value signal up operation" as the manipulated value signal. (For step controllers only)	-
57.1	LMNDN_OP 1)	BOOL	Manipulated signal down operation		FALSE	If LMNSOPON is set, the value at the input "Manipulated value signal down operation" as the manipulated value signal. (For step controllers only)	-

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In para-meter configu-ration mask
57.3	LMNRS_ON	BOOL	Simulation of the repeated manipulated value on		FALSE	If no position feedback is available, this can be simulated. The function is switched on on the input "simulation of the position feedback on". The configuration tool (controller optimization) also has access to these parameters, as at least one simulated manipulated variable is required for optimization if a step controller without position feedback is being configured. The simulated value is displayed at the parameter LMN_A. When the simulation is activated, the value of the parameter LMNRSVAL is set as the start value. CAUTION: Over time the simulation deviates increasingly from the true position feedback. (Only in the case of step controllers without analog position feedback)	-
57.4	FUZID_ON	BOOL	Fuzzy identification on		FALSE	The identification of the fuzzy algorithm is activated at the input "Switch fuzzy identification on".	-
58.0	SP_OP1)	REAL	Setpoint operation	Technical range of values (physical variable)	0.0	The configuration tool (controller optimization) has access to the through parameter "Setpoint operation". If the bit SP_OP_ON is set, the value "Setpoint operation" is used as the setpoint value.	-

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In parameter configuration mask
62.0	LMN_OP[1)]	REAL	Manipulated value operation	-100.0...100.0 (%)	0.0	The configuration tool has access to the through parameter "Manipulated variable operation". If the bit LMNOP_ON is set, the value "Manipulated value operation" is used as the manipulated value.	-
66.0	LMNRSVAL	REAL	Start value of the repeated manipulated value in simulation	-100.0...100.0 (%)	0.0	The configuration tool (controller optimization) has access to the input "Start value of the simulated position feedback". The start value of the simulation is entered at the parameter. (Only in the case of step controllers without analog position feedback)	-
70.0	cont_par	WORD	Begin of control parameters	W#16#3130	W#16#3130[2)]	The cont_par parameter may not be overwritten by the user. It characterizes the start of the controller parameter that is read from the FM and stored in the instance DB, if COM_RST = TRUE and which is transferred to the FM when LOAD_PAR = TRUE. The end of the controller parameter is the end of the instance DB.	-
72.0	P_SEL	BOOL	P action on		TRUE [2)]	The PID algorithm allows individual PID-actions to be switched on and off. The proportional action is activated when the "Activate P-action component" input is set.	PID Controller
72.1	PFDB_SEL	BOOL	P action in feedback path		FALSE [2)]	In the PID algorithm, the P and D actions can be included in the feedback path. The proportional action is in the feedback path when the "P-action component in the feedback" input is set.	PID Controller

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In parameter configuration mask
72.2	MONERSEL	BOOL	Monitoring: process variable = 0 error signal = 1		FALSE 2)	The controller possesses a limit value detector that can be applied either for the actual value or for the error signal. If the input "Monitoring: actual value = 0, control deviation = 1" is set, the control deviation will be monitored.	Alarm controller
74.0	D_EL_SEL	INT	D-element input for the controller	0 to 4 or 17	0 2)	The D-element in the PID algorithm can be laid to a separate input. This is selected at the input "D-element input". 0: Error signal/Negative deviation 1 to 4: Analog input 1 to 4 17: Negative actual process value, D-action component in the feedback	control deviation (...) controller
76.0	SP_HLM	REAL	Setpoint high limit	> SP_LLM (physical variable)	100.0 2)	The setpoint is always limited to a high and a low limit. The "Setpoint high limit" input specifies the upper limit.	Limiting setpoint controller
80.0	SP_LLM	REAL	Setpoint low limit	< SP_HLM (physical variable)	0.0 2)	The setpoint is always limited to a high and a low limit. The "Setpoint low limit" input specifies the lower limit.	Limiting setpoint controller
84.0	H_ALM	REAL	High limit alarm	> H_WRN (physical variable)	100.0 2)	Four limits can be assigned for monitoring the process variable or the negative deviation. The "Upper limit alarm" input specifies the highest limit.	Alarm controller
88.0	H_WRN	REAL	High limit warning	H_ALM...L_WRN (physical variable)	90.0 2)	Four limits can be assigned for monitoring the process variable or the negative deviation. The "Upper limit warning" input specifies the second high limit.	Alarm controller

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In parameter configuration mask
92.0	L_WRN	REAL	Low limit warning	H_WRN...L_ALM (physical variable)	10.0 2)	Four limits can be assigned for monitoring the process variable or the negative deviation. The "Lower limit warning" input specifies the second lower limit.	Alarm controller
96.0	L_ALM	REAL	Low limit alarm	< L_WRN (physical variable)	0.0 2)	Four limits can be assigned for monitoring the process variable or the negative deviation. The "Lower limit alarm" specifies the lowest limit.	Alarm controller
100.0	HYS	REAL	Hysteresis	≥ 0.0 (physical variable)	1.0 2)	To prevent flickering of the monitoring displays a hysteresis can be configured at the "hysteresis" input.	Alarm controller
104.0	DEADB_W	REAL	Dead band width	≥ 0.0 (physical variable)	0.0 2)	A dead band is applied to the negative deviation. The "Dead band width" input determines the size of the dead band.	Dead band controller
108.0	GAIN	REAL	Proportional gain	Complete range of values (dimensionless)	1.0 2)	The input "proportional gain" indicates the controller gain.	PID Controller
112.0	TI	REAL	Reset time (s)	= 0.0 or ≥ 0.5	3000.0 2)	The "integration time" input determines the time response of the integrator. If TI = 0, the integrator is deactivated	PID Controller
116.0	TD	REAL	Derivative time (s)	= 0.0 or ≥ 1.0	0.0 2)	The "derivative time" input determines the time response of the derivative unit. If TD = 0, the derivative unit is deactivated.	PID Controller
120.0	TM_LAG	REAL	Time lag of the derivative action (s)	TM_LAG ≥ 0.5	5.0 2)	The algorithm of the D-action includes a time lag that can be assigned to the "Time lag of the derivative action (s)" input.	PID Controller
124.0	LMN_SAFE	REAL	Safety manipulated value Safety manipulated variable	-100.0...100.0 (%)	0.0 2)	For the manipulated value, a security value can be configured on the "Security manipulated value" input.	Switching to safety manipulated value controller

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In parameter configuration mask
128.0	LMN_HLM	REAL	Manipulated value high limit Upper limit of manipulated value	LMN_LLM...100.0 (%)	100.0 2)	The manipulated variable is always limited to an high and a low limit. The "Upper limit of manipulated value" input specifies the upper limit. (this does not apply to step-action controllers without analog position feedback).	Limits of manipulated value controller
132.0	LMN_LLM	REAL	Manipulated value low limit Lower limit of manipulated value	-100.0...LMN_HLM (%)	0.0 2)	The manipulated variable is always limited to an high and a low limit. The "Lower limit of manipulated value" input specifies the lower limit. (this does not apply to step-action controllers without analog position feedback).	Limits of manipulated value controller
136.0	MTR_TM	REAL	Motor manipulated value (s) Motor actuating time (s)	MTR_TM ≥ 0.001	60.0 2)	The actuating time from end stop to end stop of the control valve is entered in the "Motor actuating time" parameter. (Applies only to step controllers)	Pulse-shaper controller
140.0	PULSE_TM	REAL	Minimum pulse time (s) Minimum pulse width (s)	≥ 0.0	0.2 2)	A minimum pulse length can be configured on the "minimum pulse time" parameter. (For step controllers or pulse controllers only)	Pulse-shaper controller Split-range function/ Pulse generator controller
144.0	BREAK_TM	REAL	Minimum break time (s) Minimum interpulse width (s)	≥ 0.0	0.2 2)	A minimum pulse duration can be assigned with the parameter "Minimum break time." (For step controllers or pulse controllers only)	Pulse-shaper controller Split-range/ pulse generator controller

1) You can also change these parameters via the loop display.

2) Default values of the module after the first start-up of the PID_FM FB with COM_RST = TRUE

Note

If LOAD_PAR = TRUE is set, all the control parameters are loaded permanently to the EEPROM of the FM 355.

With LOAD_OP = TRUE only the setpoint SP_RE of the operator parameters is loaded permanently to the EEPROM of the FM 355. All the other operator parameters have the values 0 or FALSE pre-assigned during the FM 355 startup.

The EEPROM of the module could be destroyed by excessive writing processes. In order to prevent this the module delays renewed writing to the EEPROM by 30 minutes.

See also

Error display from the group error LED (Page 12-1)

11.2 Instance DB of the FUZ_355 FB

Introduction

The FUZ_355 FB can be used to read the controller parameters of the fuzzy temperature controller out of the FM 355. You can then, for example, transfer these parameters back to the module after you have replaced the FM 355.

Note

You may not change the parameters determined through identification by the FM 355 since they have been optimized for the process.

The following tables list the parameters of this instance DB:

- Input parameters
- Output parameters

Input Parameters

Table 11-4 Input parameters of the instance DB for the FUZ_355 FB

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In parameter configuration mask
0.0	MOD_ADDR	INT	FM 355/455 module address		256	This input contains the module address resulting from the configuration with STEP 7.	-

Output Parameters

Table 11-5 Output parameters of the instance DB for the FUZ_355 FB

Addr-	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assignment screen form
2.0	RET_VALU	WORD	Return value SFC 58/59 SFB 52/53		0	RET_VALU includes the return value RET_VAL of the SFC 58/59. With the block for PROFINET Mode, the RET_VAL includes the 2nd and 3rd bytes from the STATUS parameter of the SFB 52/53. RET_VALU can be evaluated if an error is reported via the QMOD_F (see reference manual /2/).	-

Addr-	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assign-ment screen form
4.0	PARAFFUZ	WORD	Parameter fault display		0	On the PARAFFUZ parameter a parameterization error created by the FB FUZ_355 is displayed as follows: High byte of PARAFFUZ = 01: A parameter configuration error exists. High byte of PARAFFUZ = 00: A parameter configuration error does not exist. The low byte contains the offset of the parameter that caused the parameter configuration error, calculated from the static variable FUZ_PAR[1].	-
6.0	READ_PAR	BOOL	Read fuzzy parameters		FALSE	If the READ_PAR parameter is set, the fuzzy parameters are read out of the module and stored in the static variables of the instance DB.	-
6.1	LOAD_PAR	BOOL	Write fuzzy parameters		FALSE	If the LOAD_PAR parameter is set, the fuzzy parameters are read out of the static variables of the instance DB module and transferred to the module.	-

11.3 Instance DB of the FB FORCE355

Introduction

The FB FORCE355 is required to simulate analog or digital input values of the FM 355.

The following tables list the parameters of this instance DB:

- Input parameters
- Output parameters

Input Parameters

Table 11-6 Input parameters of the instance DB for the FORCE355 FB

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assign-ment screen form
0.0	S_AION	ARRAY [1..4] of BOOL	Switch: simulation of analog input by PV_SIM		FALSE	If, for example, the S_AION[1] switch is set to TRUE, the value PV_SIM[1] is used instead of the analog input value 1 of the module.	-
2.0	S_PVON	ARRAY [1..4] of BOOL	Switch: simulation of linearized analog input by PV_SIM		FALSE	If, for example, the S_PVON[1] switch is set to TRUE, the value PV_SIM[1] is used instead of the conditioned analog input value 1 of the module.	-

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assign-ment screen form
4.0	PV_SIM	ARRAY [1..4] of REAL	Simulated analog input value	0.0 to 20.0 [mA] or -1500 to +10000 [mV] or technical range of values	0.0	For example, input PV_SIM[1] specifies the simulation value for the analog input 1. If S_PVON = TRUE, then the preprocessed analog input value is specified in this case. If S_PVON = FALSE and S_AION = TRUE then the analog input value, which is transformed into a preprocessed value by means of the preprocessing functions, is specified in mA or mV.	-
20.0	S_DION	ARRAY [1..8] of BOOL	Switch: simulation of digital input by DI_SIM		FALSE	If, for example, S_DION[1] is set to TRUE, the value DI_SIM[1] is used as the digital value instead of the digital input value 1 of the module.	-
22.0	DI_SIM	ARRAY [1..8] of BOOL	Simulated digital input value		FALSE		-
24.0	MOD_ADDR	INT	FM 355/455 module address		256	The module address that resulted from the configuration with STEP 7 is given at this input.	-

Output Parameters

Table 11-7 Output parameters of the instance DB to the FB FORCE355

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assign-ment screen form
26.0	RET_VALU	WORD	Return value SFC 58/59 SFB 52/53		0	RET_VALU includes the return value RET_VAL of the SFC 58/59. With the block for PROFINET Mode, the RET_VAL includes the 2nd and 3rd bytes from the STATUS parameter of the SFB 52/53. RET_VALU can be evaluated if an error is reported via the QMOD_F (see reference manual /2/).	-

11.4 Instance DB of the READ_355 FB

Introduction

The READ_355 FB is required to read analog or digital input values out of the FM 355.

The following tables list the parameters of this instance DB:

- Input parameters
- Output parameters

Input Parameters

Table 11-8 Input parameters of the instance DB for the READ_355 FB

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assign-ment screen form
0.0	MOD_ADDR	INT	FM 355/455 module address		256	This input contains the module address resulting from the configuration with STEP 7.	-

Output Parameters

Table 11-9 Output parameters of the instance DB for the READ_355 FB

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assign-ment screen form
2.0	CJ_TEMP	REAL	Cold junction temperature		0.0	On the CJ_TEMP output, the measured reference junction temperature is displayed by the module if a thermocouple element input is configured and the reference junction temperature is not configured.	-

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assign-ment screen form
6.0	STAT_DI	ARRAY[1..8] of BOOL	Status of binary input DI1 to DI8		FALSE	The states of digital inputs 1 to 8 are displayed at the STAT_DI parameters.	-
(channel number) x 8	DIAG[x].PV_PER	ARRAY [1..4] of STRUCT	Analog input (0 to 20mA, -1500 to 10000 mV)		0.0	The parameter DIAG[1].PV_PER displays, for example, the analog input value of the module in the unit mA or mV.	-
(channel number) x 8 + 4	DIAG[x].PV_PHY	ARRAY [1..4] of STRUCT	Linearized analog input (physical)		0.0	The conditioned analog input value of the module is, for example, displayed at the parameter DIAG[1].PV_PHY.	-
40.0	RET_VALU	WORD	Return value SFC 58/59 SFB 52/53		0	RET_VALU includes the return value RET_VAL of the SFC 58/59. With the block for PROFINET Mode, the RET_VAL includes the 2nd and 3rd bytes from the STATUS parameter of the SFB 52/53. RET_VALU can be evaluated if an error is reported via the QMOD_F (see reference manual /2/).	-

11.5 Instance DB of the CH_DIAG FB

Introduction

The FB CH_DIAG is needed to read out additional channel-specific diagnostic variables from the module.

The following tables list the parameters of this instance DB:

- Input parameters
- Output parameters

Input Parameters

Table 11-10 Input parameters of the instance DB for the CH_DIAG FB

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assign-ment screen form
0.0	MOD_ADDR	INT	FM 355/455 module address		256	The module address that resulted from the configuration with STEP 7 is given at this input.	-
2.0	CHANNEL	INT	Channel Number	1 to 4	1	The number of the controller channel to which the instance DB refers is configured at the "Channel number" input.	-
4.0	SP_R	REAL	Setpoint ratio		0.0	If a ratio controller is set, the input value of the setpoint value is assigned to the parameter.	-
8.0	PV_R	REAL	Process variable ratio		0.0	The parameter only has the following value assigned to it at a set ratio controller: (Process value A - Setpoint value offset) / Process value D	-

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assign-ment screen form
12.0	DIF_I	REAL	Derivative unit input		0.0	The input variable of the D-action component at the DIF_I parameter. This is particularly of interest if, for example, an analog input is configured as the input variable of the D-action component.	-
16.0	TRACKPER	REAL	Input value for LMN tracking		0.0	The TRACKPER parameter shows the input size at which the set value is being followed up if the controller is switched to set value follow-up.	-
20.0	IDSTATUS	WORD	Status of identification		0.0	This parameter is described in chapter "Parameter optimization with temperature controllers".	-
22.0	LMN_P	REAL	Proportionality component		0.0	The P part of the manipulated variable is shown on the LMN_P parameter.	-
26.0	LMN_I	REAL	Integral component		0.0	The I-action component of the manipulated variable is displayed at the LMN_I parameter.	-
30.0	LMN_D	REAL	Derivative component		0.0	The D part of the manipulated variable is shown on the LMN_D parameter.	-

Output Parameters

Table 11-11 Output parameters of the instance DB for the CH_DIAG FB

Ad-dress	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assign-ment screen form
34.0	RET_VALU	WORD	Return value SFC 58/59 SFB 52/53		0	RET_VALU includes the return value RET_VAL of the SFC 58/59. With the block for PROFINET Mode, the RET_VAL includes the 2nd and 3rd bytes from the STATUS parameter of the SFB 52/53. RET_VALU can be evaluated if an error is reported via the QMOD_F (see reference manual /2/).	-

11.6 Instance DB of the PID_PAR FB

Introduction

The FB PID_PAR is used to change parameters on-line which are not contained in FB PID_FM.

The following tables list the parameters of this instance DB:

- Input parameters
- Output parameters

Input Parameters

Table 11-12 Input parameters of the instance DB for the PID_PAR FB

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assign-ment screen form
0.0	COM_RST	BOOL	Read parameters from system data		TRUE	If the parameter COM_RST = TRUE is set, the PID_PAR FB carries out an initialization run. In the process the parameters are read from the system data of the CPU and saved in the instance DB.	-
2.0	MOD_ADDR	INT	FM 355/455 module address		256	The module address that resulted from the configuration with STEP 7 is given at this input.	-
4.0	CHANNEL	INT	Channel Number	1 to 4	1	The number of the controller channel to which the instance DB is referenced is configured at input "channel number".	-
6.0	INDEX_R	INT	Index for REAL-parameter	0 to 48	0.0	Refer to the section "The PID_PAR Function Block"	-
8.0	VALUE_R	REAL	Value for REAL-parameter	Depending on the respective parameter	0.0	Refer to the section "The PID_PAR Function Block"	-
12.0	INDEX_I	INT	Index for INT parameter	0.49 to 61	0.0	Refer to the section "The PID_PAR Function Block"	-

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assign-ment screen form
14.0	VALUE_I	INT	Value for INT parameter	Depending on the respective parameter	0.0	Refer to the section "The PID_PAR Function Block"	-

Output Parameters

Table 11-13 Output parameters of the instance DB for the PID_PAR FB

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assign-ment screen form
16.0	RET_VALU	WORD	Return value SFC 58/59 SFB 52/53		0	RET_VALU includes the return value RET_VAL of the SFC 58/59. With the block for PROFINET Mode, the RET_VAL includes the 2nd and 3rd bytes from the STATUS parameter of the SFB 52/53. RET_VALU can be evaluated if an error is reported via the QMOD_F (see reference manual /2/).	-
18.0	BUSY	BOOL	BUSY value of SFC WR_REC SFB WRREC		FALSE	If BUSY = TRUE, the parameters have not yet been transferred from the module (at distributed I/Os). The call of the PID_PAR FB should then be repeated in the next cycle.	-

See also

Introduction (Page 7-23)

11.7 Instance DB of the CJ_T_PAR FB

Introduction

The FB JC_T_PAR is used to change the configured reference junction temperature on the module on-line.

The following tables list the parameters of this instance DB:

- Input parameters
- Output parameters

Input Parameters

Table 11-14 Input parameters of the instance DB for the CJ_T_PAR FB

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assign-ment screen form
0.0	COM_RST	BOOL	Read parameters from system data		-	If the parameter COM_RST = TRUE is set, the CJ_T_PAR FB carries out an initialization run. In the process the parameters are read from the system data of the CPU and saved in the instance DB.	-
2.0	MOD_ADDR	INT	FM 355/455 module address		256	The module address that resulted from the configuration with STEP 7 is given at this input.	-
4.0	CJ_T	REAL	Cold junction temperature	Depending on the sensor type	0.0	The reference junction temperature can be specified at the CJ_T parameter.	-

Output Parameters

Table 11-15 Output parameters of the instance DB for the CJ_T_PAR FB

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assign-ment screen form
8.0	RET_VALU	WORD	Return value SFC 58/59 SFB 52/53		0	RET_VALU includes the return value RET_VAL of the SFC 58/59. With the block for PROFINET Mode, the RET_VAL includes the 2nd and 3rd bytes from the STATUS parameter of the SFB 52/53. RET_VALU can be evaluated if an error is reported via the QMOD_F (see reference manual /2/).	-
10.0	BUSY	BOOL	BUSY value of SFC 59 SFB 53		FALSE	If BUSY = TRUE, the parameters have not yet been transferred from the module (at distributed I/Os). The call of the PID_PAR FB should then be repeated in the next cycle.	-

11.8 Assignment of the DBs for Operator Control and Monitoring via OP

Introduction

The variable interface of the FM 355 contains four data blocks with the block numbers 101 to 104 for the controller channels 1 to 4 that are used for operator control and monitoring of the FM 355 via an OP.

The following tables list the parameters of these instance DBs:

- Input parameters
- Output parameters
- In/Out parameters

Input Parameters

Table 11-16 Input parameters of the DBs for operator control and monitoring

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assign-ment screen form
0.0	SP_HLM 1)	REAL	Setpoint high limit	> SP_LLM (physical variable)	100.0	The setpoint is always limited by an upper and lower limit. The "Setpoint high limit" input specifies the upper limit.	Limiting setpoint controller
4.0	SP_LLM 1)	REAL	Setpoint low limit	< SP_HLM (physical variable)	0.0	The setpoint is always limited by an upper and lower limit. The "Setpoint low limit" input specifies the lower limit.	Limiting setpoint controller
8.0	H_ALM 1)	REAL	High limit alarm	> H_WRN (physical variable)	100.0	Four limits can be assigned for monitoring the process variable or the negative deviation. The "Upper limit alarm" input specifies the highest limit.	Alarm controller

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assign-ment screen form
12.0	H_WRN 1)	REAL	High limit warning	H_ALM...L_WRN (physical variable)	90.0	Four limits can be assigned for monitoring the process variable or the negative deviation. The "Upper limit warning" input specifies the second high limit.	Alarm controller
16.0	L_WRN 1)	REAL	Low limit warning	H_WRN...L_ALM (physical variable)	10.0	Four limits can be assigned for monitoring the process variable or the negative deviation. The "Lower limit warning" input specifies the second lower limit.	Alarm controller
20.0	L_ALM 1)	REAL	Low limit alarm	< L_WRN (physical variable)	0.0	Four limits can be assigned for monitoring the process variable or the negative deviation. The "Lower limit alarm" specifies the lowest limit.	Alarm controller
24.0	HYS 1)	REAL	Hysteresis	≥ 0.0 (physical variable)	1.0	To prevent flickering of the monitoring displays a hysteresis can be configured at the "hysteresis" input.	Alarm controller
28.0	DEADB_W 1)	REAL	Dead band width	≥ 0.0 (physical variable)	0.0	A dead band is applied to the negative deviation. The "Dead band width" input determines the size of the dead band.	Dead band controller
32.0	GAIN 1)	REAL	Proportional gain	Complete range of values (dimensionless)	1.0	The input "proportional gain" indicates the controller gain.	PID Controller
36.0	TI 1)	REAL	Reset time (s)	= 0.0 or ≥ 0.5	3000.0	The "integration time" input determines the time response of the integrator. If TI = 0, the integrator is deactivated	PID Controller

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assign-ment screen form
40.0	TD 1)	REAL	Derivative time (s)	= 0.0 or ≥ 1.0	0.0	The "derivative time" input determines the time response of the derivative unit. If TD = 0, the derivative unit is de-activated.	PID Controller
44.0	TM_LAG 1)	REAL	Time lag of the derivative action (s)	TM_LAG ≥ 0.5	5.0	The algorithm of the D part includes a time lag that can be assigned to the "Time lag of the D part" input.	PID Controller
48.0	LMN_SAFE 1)	REAL	Safety manipulated value	-100.0...100.0 (%)	0.0	For the manipulated value, a security value can be configured on the "Security manipulated value" input.	Switching to safety manipulat ed value controller
52.0	LMN_HLM 1)	REAL	Manipulated value high limit	LMN_LLM...100.0 (%)	100.0	The manipulated variable is always limited to an high and a low limit. The "Upper limit of manipulated value" input specifies the upper limit. (this does not apply to step-action controllers without analog position feedback).	Limits of manipulat ed value controller
56.0	LMN_LLM 1)	REAL	Manipulated value low limit	-100.0...LMN_HLM (%)	0.0	The manipulated variable is always limited to an high and a low limit. The "Lower limit of manipulated value" input specifies the lower limit. (this does not apply to step-action controllers without analog position feedback).	Limits of manipulat ed value controller

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assign-ment screen form
60.0	MTR_TM 1)	REAL	Motor manipulated value (s)	MTR_TM ≥ 0.001	60.0	The actuating time from end stop to end stop of the control valve is entered in the "Motor actuating time" parameter. (For step controllers only)	Pulse-shaper controller
64.0	PULSE_TM 1)	REAL	Minimum pulse time (s)	≥ 0.0	0.2	A minimum pulse length can be configured on the "minimum pulse time" parameter. (applies to step controllers or pulse controllers only)	Pulse-shaper controller Split-range function/Pulse generator controller
68.0	BREAK_TM 1)	REAL	Minimum break time (s)	≥ 0.0	0.2	A minimum pulse duration can be assigned with the parameter "Minimum break time." (applies to step controllers or pulse controllers only)	Pulse-shaper controller Split-range function/Pulse generator controller
72.0	SP_RE 2)	REAL	External setpoint	Technical range of values physical variable)	0.0	An external setpoint is connected to the controller at the "external setpoint" input.	-
76.0	LMN_RE 2)	REAL	External manipulated value	-100.0...100.0 (%)	0.0	An external manipulated value is interconnected to the controller at the input "External manipulated value".	-
80.0	LMNRSVAL 2)	REAL	Start value of the repeated manipulated value in simulation	-100.0...100.0 (%)	0.0	The configuration tool has access to the input "Start value of the simulated position feedback". The start value of the simulation is entered at the parameter. (Only in the case of step controllers without analog position feedback)	-

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assign-ment screen form
84.0	SAFE_ON 2)	BOOL	Safety position on		FALSE	If the "assume safety position" input is set, a security value is adopted as the manipulated value. Note: The actuating signal processing via LMNDN_OP, LMNUP_OP and LMNSOPON with step controllers has greater priority than the safety manipulated variable.	-
84.1	LMNTRKON 2)	BOOL	Match (LMN from analog input)		FALSE	If the input "Track (LMN via analog input)" is set, the manipulated value is tracked to an analog input. (this does not apply to step-action controllers without analog position feedback).	-
84.2	LMN_REON 2)	BOOL	External manipulated value on		FALSE	If the input "Switch external manipulated value on" is set, the external manipulated value LMN_RE is used as the manipulated value.	-
84.3	LMNRHSRE 2)	BOOL	High limit signal of repeated manipulated value		FALSE	The signal "Manipulated valve on high stop" is switched on the "high stop signal of the position feedback" input. LMNRHSRE = TRUE means: The control valve is at its upper limit. (For step controllers only)	-

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assign-ment screen form
84.4	LMNRLSRE 2)	BOOL	Low limit signal of repeated manipulated value		FALSE	The signal "Manipulated valve on low stop" is switched on the "low stop signal of the position feedback" input. LMNRLSRE = TRUE means: The control valve is at its lower limit. (For step controllers only)	-
84.5	LMNSOPON 2)	BOOL	Manipulated signal operation on		FALSE	If the bit on the input "Manipulated value signal operation on" is set, the signals LMNUP_OP and LMNDN_OP are adopted as the manipulated value signals. (For step controllers only)	-
84.6	LMNUP_OP 2)	BOOL	Manipulated signal up operation		FALSE	If LMNSOPON is set, the value at the input "Manipulated value signal up operation" as the manipulated value signal. (For step controllers only)	-
84.7	LMNDN_OP 2)	BOOL	Manipulated signal down operation		FALSE	If LMNSOPON is set, the value at the input "Manipulated value signal down operation" as the manipulated value signal. (For step controllers only)	-

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assign-ment screen form
85.0	MONERSEL 1)	BOOL	Monitoring: Process variable = 0 Error signal = 1		FALSE	The controller possesses a limit value detector that can be applied either for the actual value or for the error signal. If the input "Monitoring: actual value = 0, control deviation = 1" is set, the control deviation will be monitored.	Alarm controller
85.1	LMNRS_ON 2)	BOOL	Simulation of the repeated manipulated value on		FALSE	If no position feedback is available, this can be simulated. The function is switched on on the input "simulation of the position feedback on". CAUTION: Over time the simulation deviates increasingly from the true position feedback. (Only in the case of step controllers without analog position feedback)	-
85.2	FUZID_ON 2)	BOOL	Fuzzy identification on		FALSE	The identification of the fuzzy algorithm is activated at the input "Switch fuzzy identification on".	-
85.3	SPINT_EN 2)	BOOL	Operator input: external = 0 internal = 1		FALSE	The input "operating input: external = 0, internal = 1" determines the input that is transferred as a set value to the module. SPINT_EN = TRUE: SP_INT is transferred. SPINT_EN = FALSE: SP_RE is transferred.	-

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assign-ment screen form
85.4	P_SEL 1)	BOOL	P action on		TRUE	The PID algorithm allows individual PID-actions to be switched on and off. The proportional action is activated when the "Activate P-action component" input is set.	PID Controller
85.5	PFDB_SEL 1)	BOOL	P action in feedback path		FALSE	In the PID algorithm, the P and D actions can be included in the feedback path. The proportional action is in the feedback path when the "P-action component in the feedback" input is set.	PID Controller
86.0	D_EL_SEL 1)	INT	D-element input for the controller	0 to 4 or 17	0	The D element in the PID algorithm can be placed at a separate input. This is selected at the input "D-element input". 0: Error signal/Negative deviation 1 to 4: Analog input 1 to 4 17: Negative actual process value	control deviation (...) controller
1) Control parameters Control parameters are downloaded to the module if the I/O parameter LOAD_PAR is set. All the control parameters are loaded permanently to the EEPROM of the FM 355.							
2) Operating parameters: Operating parameters are downloaded to the module if the I/O parameter LOAD_OP is set. Only the setpoint SP_RE of the operator parameters is loaded permanently to the EEPROM of the FM 355. All the other operator parameters have the values 0 or FALSE pre-assigned during the FM 355 startup.							

Note

The EEPROM of the module could be destroyed by excessive writing processes. In order to prevent this the module delays renewed writing to the EEPROM by 30 minutes.

Output Parameters

Table 11-17 Output parameters of the DBs for operator control and monitoring

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assignment screen form
94.0	SP	REAL	Setpoint	Technical range of values (physical variable)	0.0	The setpoint value that is currently in effect is available at the "Setpoint" output.	-
98.0	PV	REAL	Process variable	Technical range of values (physical variable)	0.0	The effective process variable is output at the "process variable" output.	-
102.0	ER	REAL	Error signal	Technical range of values (physical variable)	0.0	The effective negative deviation is output at the "Negative deviation" output.	-
106.0	DISV	REAL	Disturbance variable	-100.0...100.0 (%)	0.0	The effective disturbance variable is output at the "Disturbance variable" output.	-
110.0	LMN	REAL	Manipulated value	-100.0...100.0 (%)	0.0	The effective manipulated value is output at the "Manipulated value" output. At a step controller without analog position feedback the unlimited P- + D-action component is output at the LMN parameter.	-

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the para-meter assign-ment screen form
114.0	LMN_A	REAL	Manipulated value A of split range function/repeated manipulated value	-100.0...100.0 (%)	0.0	On the output "Manipulated value A of the split range function / position feedback" in the case of continuous controllers the manipulated value A of the split range function, and with step controllers with analog position feedback, the position feedback is displayed. In the case of step controllers without analog position feedback the simulated position feedback is displayed.	-
118.0	LMN_B	REAL	Manipulated value B of split range function	-100.0...100.0 (%)	0.0	Manipulated value B of the split-range function is displayed at the output "Manipulated value B of the split-range function§ at a continuous-action controller.	-
122.0	QH_ALM	BOOL	High limit alarm reached		FALSE	The actual value or the controlled variable is monitored for four limits. Exceeding of the limit H_ALM is signaled at the "Upper limit alarm triggered" output.	-
122.1	QH_WRN	BOOL	High limit warning reached		FALSE	The actual value or the controlled variable is monitored for four limits. Exceeding of the limit H_WRN is signaled at the "Upper limit warning triggered" output.	-

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the para-meter assign-ment screen form
122.2	QL_WRN	BOOL	Lower limit warning reached		FALSE	The actual value or the controlled variable is monitored for four limits. Exceeding of the limit H_WRN is signaled at the "Lower limit warning triggered" output.	-
122.3	QL_ALM	BOOL	Low limit alarm reached		FALSE	The actual value or the controlled variable is monitored for four limits. Exceeding of the limit H_ALM is signaled at the "Lower limit alarm triggered" output.	-
122.4	QLMN_HLM	BOOL	High limit of manipulated value reached		FALSE	The manipulated variable is always limited to an high and a low limit. The "high limit of manipulated value reached" output displays the exceeding of the upper limit. (this does not apply to step-action controllers without analog position feedback).	-
122.5	QLMN_LLM	BOOL	Low limit of manipulated value reached		FALSE	The manipulated variable is always limited to an high and a low limit. The "low limit of manipulated value reached" output displays the falling short of the low limit. (this does not apply to step-action controllers without analog position feedback).	-
122.6	QSPINTON	BOOL	Internal setpoint on		FALSE	The output "Internal setpoint on" indicates that SP_INT was transferred to the module.	-

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the para-meter assign-ment screen form
123.0	QPARA_F	BOOL	Parameter assignment error		FALSE	The module checks the validity of the parameters. A parameter configuration error is displayed at the "Parameter configuration error" output. You can also read out these parameter assignment errors by using the **PLC > Parameter Assignment Error** menu of the parameter configuration interface.	-
123.1	QCH_F	BOOL	Channel error		FALSE	The output "Channel error" is set if the controller channel cannot supply any valid results. "Channel error" (e.g. wire break) is also set if QPARA_F = 1 or QMOD_F = 1. If QCH_F = TRUE, then the precise error information in the diagnostic record DS1 of the module is read off.	-
123.2	QUPRLM	BOOL	Limit of positive setpoint inclination reached		FALSE	The setpoint is limited to a positive and negative gradient. If the output "Limit of positive setpoint inclination triggered" is set, the positive setpoint inclination is limited.	-
123.3	QDNRLM	BOOL	Limit of negative setpoint inclination reached		FALSE	The setpoint is limited to a positive and negative gradient. If the "negative set value inclination reached" output is set, then the set value inclination is restricted.	-

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the para-meter assign-ment screen form
123.4	QSP_HLM	BOOL	High limit of setpoint reached		FALSE	The setpoint is always limited to a high and a low limit. The output "Upper limit of setpoint value triggered" indicates that the upper limit has been exceeded.	-
123.5	QSP_LLM	BOOL	Low limit of setpoint reached		FALSE	The setpoint is always limited to a high and a low limit. The "low limit of set value reached" output displays the falling short of the low limit.	-
123.6	QSPOPON	BOOL	Setpoint operation on		FALSE	The output "set value operation on" indicates whether the set value is being operated by the configuration tool (circle diagram). If the bit is set, the value SP_OP is used as the setpoint value.	-
123.7	QLMNSAFE	BOOL	Safety operation		FALSE	If the output "Safety mode" is set, the safety manipulated value is output as the manipulated value.	-
124.0	QLMNOPON	BOOL	Manipulated value operation on		FALSE	The output "Manipulated value operation on" indicates whether the manipulated value is being operated via the configuration tool (loop display). If the bit is set, the value LMN_OP is used as the manipulated value.	-
124.1	QLMNTRK	BOOL	Follow-up operation		FALSE	The output "Follow-up mode" indicates whether the manipulated value is tracked via an analog input.	-

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the para-meter assign-ment screen form
124.2	QLMN_RE	BOOL	Manual = 1 Automatic = 0		FALSE	The output "Manual = 1; Automatic = =0" indicates whether the manipulated value is set to the external manipulated value LMN_RE (Manual = 0) or not.	-
124.3	QLMNR_HS	BOOL	High limit signal of repeated manipulated value		FALSE	The output "Upper end stop signal of position feedback" indicates whether the control valve is at its upper limit. QLMNR_HS = TRUE means: The control valve is at its upper limit. (For step controllers only)	-
124.4	QLMNR_LS	BOOL	Low limit signal of repeated manipulated value		FALSE	The output "Lower end stop signal of position feedback" indicates whether the control valve is at its lower limit. QLMNR_LS = TRUE means: The control valve is at its lower limit. (For step controllers only)	-
124.5	QLMNR_ON	BOOL	Repeated manipulated value on		FALSE	The output "position feedback on" shows the set mode "step controller with position feedback" or "step controller without position feedback".	-
124.6	QFUZZY	BOOL	PID algorithm = 0 fuzzy = 1		FALSE	If the output "PID algorithm = 0, Fuzzy = 1" is set, the controller operates with the fuzzy algorithm.	-

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the para-meter assign-ment screen form
124.7	QSPLEPV	BOOL	Fuzzy display: Setpoint < process variable		FALSE	The output "Display of FUZZY controller: set value < actual value" is set when the fuzzy controller is switched on, if the set value is less than the effective actual value.	-
125.0	QSPR	BOOL	Split-range operation		FALSE	If the output "Split-range operation" is set, the continuous controller is operating in split-range mode.	-
125.1	QLMNUP	BOOL	Manipulated signal up		FALSE	Is the output "Manipulated value signal up". (For step controllers or pulse controllers only)	-
125.2	QLMNDN	BOOL	Manipulated signal down		FALSE	Is the output "Manipulated value signal down". (For step controllers or pulse controllers only)	-
125.4	QBACKUP	BOOL	backup		FALSE	0= No backup state (CPU in RUN) 1= Backup state (CPU in STOP or failed)	-
125.5	QID	BOOL	Identification in work		FALSE	QID = TRUE shows that an identification is running (not that it is switched on). After the end of the identification the identification result can be read off from the parameters IDSTATUS of the FB CH_DIAG.	-

Addr.	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the para-meter assign-ment screen form
125.6	QMAN_FC	BOOL	Manual mode or anti-reset-windup by follower controller		FALSE	The controller is a master controller which is tracked by manual operation of a secondary controller is tracked to its process variable or whose integral component is halted because the setpoint value or manipulated variable of the secondary controller is in the limitation.	-
126.0	RET_VALU	INT	Return value SFC 58/59 SFB 52/53		0	RET_VALU includes the return value RET_VAL of the SFC 58/59. With the block for PROFINET Mode, the RET_VAL includes the 2nd and 3rd bytes from the STATUS parameter of the SFB 52/53. RET_VALU can be evaluated if an error is reported via the QMOD_F (see reference manual /2/).	-

In/Out Parameters

Table 11-18 I/O parameters of the DBs for operator control and monitoring

Address	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assign-ment screen form
128.0	SP_INT	REAL	Internal setpoint	Technical range of values (physical variable)	0.0	The through parameter "internal set value" serves to specify a set value by means of operating and monitoring functions.	-
132.0	SP_OP 2)	REAL	Setpoint operation	Technical range of values (physical variable)	0.0	The configuration tool (loop display) has access to the through parameter "Setpoint operation". If the bit SP_OP_ON is set, the value "Setpoint operation" is used as the setpoint value.	-
136.0	LMN_OP 2)	REAL	Manipulated value operation	-100.0...100.0 (%)	0.0	The configuration tool (loop display) has access to the through parameter "Manipulated variable operation". If the bit LMNOP_ON is set, the value "Manipulated value operation" is used as the manipulated value.	-
140.0	SP_OP_ON 2)	BOOL	Setpoint operation on		FALSE	The configuration tool (circle diagram) has access to the through parameter "Set value operation on". If the bit is set, the value SP_OP is used as the setpoint value.	-
140.1	LMNOP_ON 2)	BOOL	Manipulated value operation on		FALSE	The configuration tool (circle diagram) has access to the through parameter "Manipulated variable operation on". If the bit is set, the value LMN_OP is used as the manipulated value.	-

Address	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assign-ment screen form
140.2	LOAD_PAR	BOOL	Load control parameter to FM 355/455		FALSE	If the through parameter "Load control parameter to FM 355/455" is set, the control parameters are loaded into the module and the through parameter is reset.	-
140.3	LOAD_OP	BOOL	Load operator parameter to FM 355/455		FALSE	If the through parameter "Load operator parameter to FM 355/455" is set, the operating parameters are loaded into the module and the through parameter is reset.	-
1) Control parameters Control parameters are downloaded to the module if the in/out parameter LOAD_PAR is set. All the control parameters are loaded permanently to the EEPROM of the FM 355.							
2) Operating parameters Operating parameters are downloaded to the module if the in/out parameter LOAD_OP is set.							

See also

Error display from the group error LED (Page 12-1)

Parameter optimization with temperature controllers (Page 3-41)

Faults and Diagnostics 12

12.1 Error display from the group error LED

When does the group error LED light up?

If the red group error LED lights up, there is either an error on the module (internal error) or in the line connections (external error).

If the yellow LED flashes, then the firmware has been deleted. This status can only occur in the case of faulty hardware or if the loading procedure of the firmware is aborted.

Which errors are displayed?

The following errors are displayed by the group error LED lighting up:

Type of error	Diagnostic message	Possible cause	Correction
Internal errors	Module defective	Hardware error	Replace the module
	Time watchdog tripped	Hardware error	Replace the module
	EEPROM content is invalid	Failure of the supply voltage when configuring	Reconfigure module
External errors	Incorrect parameters in module	Incorrect parameters have been transferred to the module	Reconfigure module
	Errors with the analog inputs or analog outputs	Analog input hardware error	Replace the module
		Analog input wire break	Remedy wire break
		Analog input measuring range violation (underrange)	Check measuring signal
		Analog input measuring range violation (overrange)	Check measuring signal
		Analog output wire break	Remedy wire break
		Analog output short circuit	Eliminate short circuit
	Missing external auxiliary supply	24 V supply missing	Restore 24 V supply

Diagnostic interrupt in the case of errors

All errors can trigger a diagnostic interrupt if you have enabled the diagnostic interrupt in the respective parameterization screen. From the diagnostic data records DS0 and DS1 you can see which errors have caused the LED to light up. The assignment of the diagnostic data records DS0 and DS1 is described in the next section.

12.2 Triggering diagnostic interrupts

What is a diagnostic interrupt?

If the user program reacts to an internal or external error, you can configure a diagnostic interrupt that interrupts the cyclic program of the CPU and calls the diagnostic interrupt OB, OB 82.

Which events can trigger a diagnostic interrupt?

The list shows which events can trigger a diagnostic interrupt:

- The module has not been configured or is incorrectly configured
- Module defective
- Wire break with analog inputs (only 4 to 20 mA)
- Overflow and underflow with analog inputs
- Load break and short circuit with analog outputs

Default setting

The diagnostic interrupt is blocked by default.

Enabling the diagnostic interrupt

In the "Basic parameters" screen you can block or enable the diagnostic interrupt for the module.

Responses to an interrupt-triggering event

The following happens when an event occurs that could trigger a diagnostic interrupt:

- The diagnostic information is stored in the diagnostic records DS0 and DS1 on the module.
- The group error LED lights up.
- The diagnostic interrupt OB (OB 82) is called.
- The diagnostic record DS0 is entered in the start information of the diagnostic interrupt OB.
- If there is no hardware fault, the module continues to control.

If no OB 82 is programmed, the CPU goes to STOP.

Diagnostic data record DS0 and DS1

The information as to which event has triggered a diagnostic interrupt is stored in the diagnostic data records DS0 and DS1. The diagnostic data record DS0 contains four bytes, the DS1 16 bytes, whereby the first four bytes are identical to those of the DS0.

Reading the Record from the Module

Diagnostic data record DS0 is automatically transferred to the start information when the diagnostic OBs are called. There these four bytes are stored in the local data (byte 8 - 11) of the OB 82.

The diagnostic data record DS1 (and hence also the content of the DS0) can be read from the module by means of SFC 59 "RD_REC" or SFB 52 "RDREC". It only makes sense to do this, if a fault in a channel is signaled in DS0.

The SFC 59 or SFB 52 must be called in the same OB as the FB PID_FM. This is achieved by the following measure: Set a bit while the OB 82 is being executed. Query this bit in the OB, in which the FB PID_FM is also called, and then, with a set bit call the SFC 59 or SFB 52.

How Does the Diagnostics Text Appear in the Diagnostics Buffer?

If you want to enter the diagnostics message in the diagnostics buffer, you must call the SFC 52 "Enter user-specific message in diagnostics buffer" in the user program. The event number of the respective diagnostics message is specified in the input parameter EVENTN. The interrupt is entered in the diagnostics buffer with x=1 as incoming and with x=0 as outgoing. The diagnostics buffer contains the relevant diagnostics text in the "Meaning" column as well as the time of the entry.

Assignments of the Diagnostics Record DS0 in the Start Information

The following table shows the assignments of the diagnostics record DS0 in the start information. All unlisted bits are not significant and are set to zero.

Table 12-1 Assignments of diagnostics record DS0

Byte	Bit	Meaning	Note	Event No.
0	0	Module malfunction	Is set at every diagnostics event	8:x:00
	1	Internal fault	Is set at all internal faults: • Watchdog time-out • EEPROM contents invalid. Module starts up without controlling and waits for renewed parameter configuration by the CPU. • EPROM error • ADC/DAC fault • Analog input, hardware fault	8:x:01
	2	External error	Is set at all external errors: • Missing external auxiliary supply • Parameter configuration faulty • Analog input, wire breakage (only range 4 to 20 mA) • Analog input, measuring range violation (underrange) • Analog input, measuring range violation (overrange) • Analog output, wire breakage • Analog output, short circuit	8:x:02

Byte	Bit	Meaning	Note	Event No.
	3	Fault in a channel	See DS1, from byte 7, for further breakdown	8:x:03
	4	Missing external auxiliary supply	24 V power supply of the FM 355 failed	8:x:04
	6	EEPROM contents invalid	Failure of the supply voltage during a writing process to the EEPROM. The module starts up with default parameters.	8:x:03
	7	Parameter configuration faulty	The module cannot use a parameter. Reason: Parameter unknown or impermissible combination of parameters. Refer to the menu **PLC > Parameter Assignment Error**	8:x:07
1	0 ... 3	Module class	Always has 8 assigned	–
	4	Channel-specific diagnostics	Is set if the module can supply additional channel information and if a channel error exists (refer to DS 1 Byte 7 to 12)	–
2	3	Watchdog time-out	Hardware fault	8:x:33
3	2	EPROM error	Module defective	8:x:42
	4	ADC/DAC fault	Module defective	8:x:44

Assignments of Diagnostics Record DS1

The diagnostics record DS1 consists of 16 bytes. The first 4 bytes are identical with diagnostics record DS0. The following table shows the assignment of the remaining bytes. All unlisted bits are not significant and are set to zero.

Table 12-2 Assignment of Bytes 4 to 12 of the diagnostics record DS1

Byte	Bit	Meaning	Note		Event No.
4	0 ... 7	Channel type	Always has 75H assigned		–
5	0 ... 7	Length of the diagnostic information	Always has 8 assigned		–
6	0 ... 7	Number of channels	Always has 5 assigned (4 controllers + 1 reference channel)		–
7	0 ... 7	Channel error vector	One bit is assigned to each channel		–
8	0	Analog input, hardware fault	Channel-specific diagnostics channel 1		8:x:B0
	1	Unused			8:x:B1
	2	Analog input wire break (only area 4 to 20 mA)			8:x:B2
	3	Unused			8:x:B3
	4	Analog input below measuring range			8:x:B4
	5	Analog input, measuring range violation (overrange)			8:x:B5
	6	Analog output, wire breakage		Only with the current output of the C controller	8:x:B6

Byte	Bit	Meaning	Note		Event No.
	7	Analog output, short circuit		Only with the voltage output of the C controller	8:x:B7
9	0 ... 7	See Byte 8	Channel-specific diagnostics channel 2		See above
10	0 ... 7	See Byte 8	Channel-specific diagnostics channel 3		See above
11	0 ... 7	See Byte 8	Channel-specific diagnostics channel 4		See above
12	0 ... 5	See Byte 8	Diagnostics for reference channel		See above

12.3 Measuring transformer error

Faults at Measuring Transducers

The following measuring transducer faults can be recognized by the controller module:

- Measuring range violation (underrange)
- Measuring range violation (overrange)
- Wiring breakage (not at all measuring ranges)

If one of these faults occurs, the group error bit "External error" is set in the diagnostics record DS0 and the channel-specific error bits in the diagnostics record DS1 (refer to the tables in the previous section). When these faults disappear, the corresponding bits are reset.

The following table shows at which limits in the individual measuring ranges the error bits are set and reset:

Measuring range	Error bit measuring range violation (underrange) at ...	Error bit measuring range violation (overrange) at ...	Error bit wire breakage indication
	DS1: Byte 10 to 26, Bit 4	DS1: Byte 10 to 26, Bit 5	DS1: Byte 10 to 26, Bit 2
0 to 20 mA	< –3.5 mA	> 23.5 mA	–
4 to 20 mA	Error bit = 1 at < 3.6 mA Error bit = 0 at < 3.8 mA	> 22.8 mA	Error bit = 1 at < 3.6 mA Error bit = 0 at < 3.8 mA
0 V to 10 V	<–1.175 V	> 11.75 V	–
Pt 100 (–200 to 850°C) (–328 to 1562°F)	< 30.82 mV	> 650.46 mV	–
Pt 100 (–200 to 556°C) (–328 to 1032°F)	< 30.82 mV	> 499.06 mV	–
Pt 100 (–200 to 130°C) (–328 to 264°F)	< 30.82 mV	> 254.12 mV	–
Thermocouple Type B	< 0 mV	> 13.81 mV	–
Thermocouple Type J	< –8.1 mV	> 69.54 mV	–
Thermocouple Type K	< –6.45 mV	> 54.88 mV	–
Thermocouple Type R	< –0.23 mV	> 21.11 mV	–
Thermocouple Type S	< –0.24 mV	> 18.7 mV	–
Free thermocouple	< Lower input value of the polyline	< Upper input value of the polyline	–

Examples 13

13.1 Application example for the FM 355 S

Introduction

The FM_PIDEx project contains the example "SIMATIC 300 Station1 (S)" that shows you the operation of the controller module S at a system simulated in the CPU. This means that you can test the module without a real process.

Prerequisites

Requirements for working with the example program:

- CPU 314 is inserted at Slot 2
- FM 355 S is plugged into slot 4
- CPU and FM 355 S are supplied with voltage
- There is an online connection PG / PC to the CPU

If you wish to work with a different CPU or FM 355, you must adapt the example under Configure hardware.

Load the sample program

To install the program, proceed as follows:

1. Download the user program blocks from example 355 S to the CPU.
2. In "HW Config: configure hardware", launch the parameterization screen of the FM 355.
3. Use the **Test > ...> Open instance DB** menu item to open the DB 31.

You can now work with the loop display, the curve recorder and the controller optimization.

Application of the Example Program

The example (Example 355 S) includes a step controller in conjunction with a simulated control section that comprises a 3rd arrangement delay element (PT3).

The example program can be used to create a step controller without any difficulty and to configure and test it in all its properties in an offline interaction with a typical system arrangement.

The example program makes it easy to understand the functionality and configuration of controllers with discontinuous output, such as they are very often used to control systems with motor-controlled actuators. It can therefore also be used for familiarizing and training.

You approximate the controlled system to the properties of the real process by selecting the parameters correspondingly. The configuration tool can be used to find a set of suitable controller characteristics through identification of the model system.

Functions of the Example Program

The example Example 355 S essentially comprises the two function blocks PID_FM (FB 31) and PROC_S (FB 100). PID_FM embodies the step controller while PROC_S simulates a controlled system with the function elements "Valve" and PT3 (refer to the figure below). Information about the position of the actuator and, if appropriate, stop signals that have been reached are transferred to the machine in addition to the controlled variable.

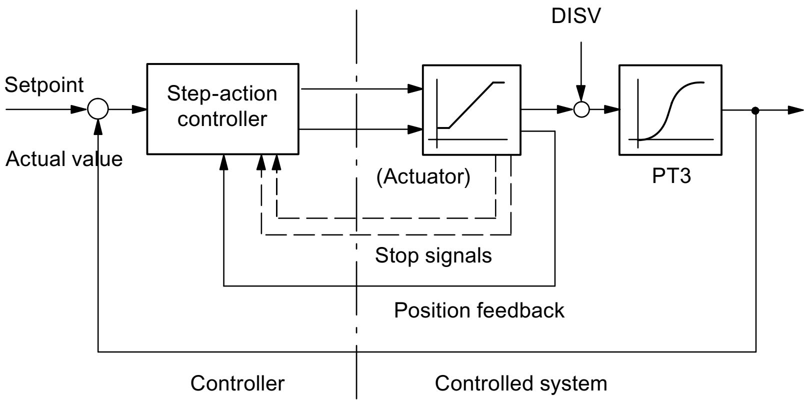


Figure 13-1 Example Example 355 S, control circuit

The PROC_S function block simulates a series connection that consists of the integrating actuator and three first-order time delays (refer to the following figure). The disturbance variable DISV is always added to the output signal of the actuator so that system disturbances can be fed forward manually at this point. The static system gain can be determined by means of the GAIN factor.

The parameter for the motor actuating time MTR_TM defines the time that the actuator requires to pass from end stop to end stop.

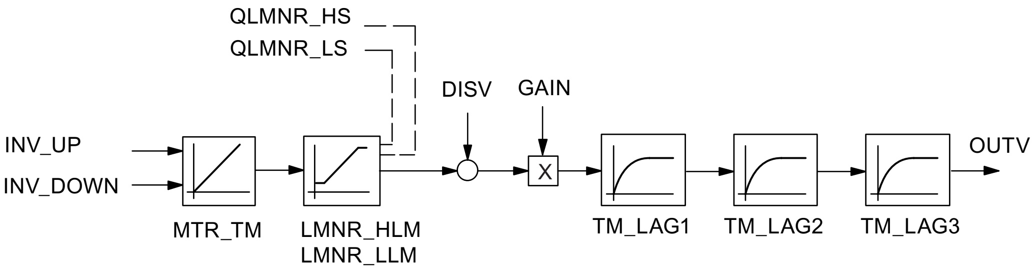


Figure 13-2 Structure and parameters of the controlled system block PROC_S

Block Structure

Example 1 consists of the function APP_1, that encompasses the blocks for the controller and the simulated controlled system, as well as of the call blocks for restarting (OB 100) and a watchdog interrupt level (OB 35 with 100 ms cycle) .

Table 13-1 Blocks of Example 1

Block	Name (in the toolbar)	Description
OB 100		Restart OB
OB 35		Time-controlled OB: 100 ms
FC100	APP_1	Example 1
FC101	SIM_355	Process value transfer in the controller module S
FB 31	PID_FM	Step controller in the controller module S
FB 100	PROC_S	Controlled system for step controller
DB 100	PROCESS	Instance DB for PROC_S
DB 31	DB_PID_FM	Instance DB for PID_FM

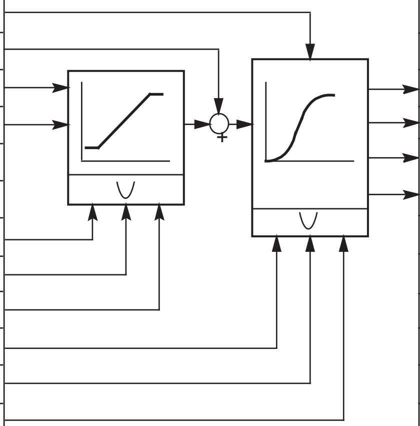
Parameters of the Model Controlled System for Step Controller

The following figure shows the function scheme and the parameters of the controlled system.

Input parameters

Parameter	Type	*)
COM_RST	BOOL	FALSE
CYCLE	TIME	T#1s
GAIN	REAL	0.0
DISV	REAL	0.0
INV_UP	BOOL	FALSE
INV_DOWN	BOOL	FALSE
LMNR_HLM	REAL	100.0
LMNR_LLM	REAL	0.0
MTR_TM	TIME	T#30s
TM_LAG1	TIME	T#10s
TM_LAG2	TIME	T#10s
TM_LAG3	TIME	T#10s

PROC_S (FB 100)



Output parameters

Signal	Type	*)
QLMNR_HS	BOOL	FALSE
OUTV	REAL	0.0
QLMNR_LS	BOOL	FALSE
LMNR	REAL	0.0

Figure 13-3 Function scheme and parameters of the system model PROC_S

* Default setting when the instance DB is created

Parameters and Step Response

The reaction of a control loop with simulated PT 3rd-order controlled system is shown by means of a concrete parameter configuration of the step controller with PI-action and activated dead band. The set system parameters with 10 s delay time each approximately simulate the behavior of a rapid temperature process or a filling level control system.

Setting one of the delay times to TM_LAGx = 0 s reduces the order of the system by one degree.

The curve diagram (configuration tool) shows the dynamic and transient response of the closed loop circuit after a setpoint value change of 60 percent (refer to the figure below). The table contains the currently set values of the relevant parameters for controller and controlled system.

Parameter	Type	Parameterization	Description
Controller:			
GAIN	REAL	0.31	P-action coefficient
TI	TIME	19.190 s	Integration time
MTR_TM	TIME	20 s	Motor actuating time
PULSE_TM	TIME	100 ms	Minimum pulse time
BREAK_TM	TIME	100 ms	Minimum break time
DEADB_ON	BOOL	TRUE	Dead Band On
DEADB_W	REAL	0.5	Dead band width
Controlled system			
CYCLE	TIME	100 ms	Sampling time
GAIN	REAL	1.5	Servo gain
MTR_TM	TIME	20 s	Motor actuating time
TM_LAG1	TIME	10 s	Time lag 1
TM_LAG2	TIME	10 s	Time lag 2
TM_LAG3	TIME	10 s	Time lag 3

Step Response

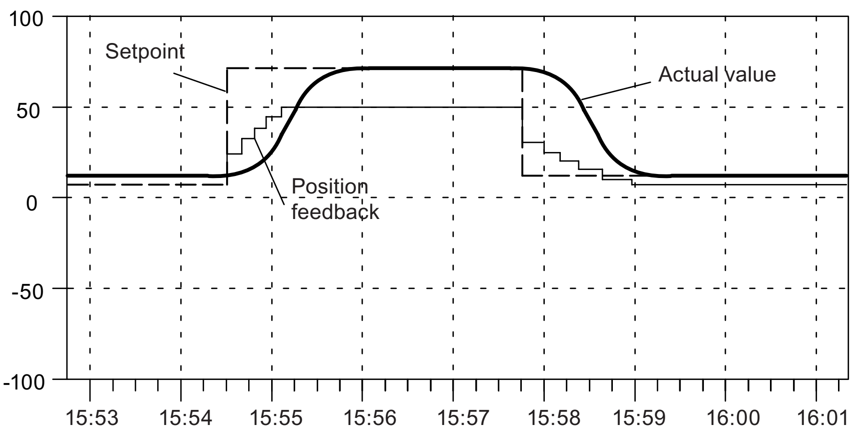


Figure 13-4 Control loop with step controller after setpoint step change

13.2 Application example for the FM 355 C

Introduction

The project FM_PIDEx can be found in the example "SIMATIC 300 Station2 (C)", and it enables you to operate the FM 355 C in a section that is simulated in the CPU. This means that you can test the module without a real process.

Prerequisites

Requirements for working with the example program:

- CPU 314 is inserted at Slot 2
- FM 355 C is plugged into slot 4
- CPU and FM 355 C are supplied with voltage
- There is an online connection PG / PC to the CPU

If you wish to work with a different CPU or FM 355, you must adapt the example under Configure hardware.

Load the sample program

To install the program, proceed as follows:

1. Download the user program blocks from example 355 C to the CPU.
2. In "HW Config: configure hardware", launch the parameterization screen of the FM 355.
3. Use the **Test > ...> Open instance DB** menu item to open the DB 31.

You can now work with the loop display, the curve recorder and the controller optimization.

Application of the Example Program

The example (Example 355 C) includes a continuous controller in conjunction with a simulated control section that comprises a 3rd arrangement delay element (PT3).

The example program can be used to generate a PID controller without any difficulty and to configure and test it in all its properties in an offline interaction with a typical system arrangement.

The example program makes it easy to understand the functionality and configuration of controllers with an analog output signal, such as they are very often used to control systems with actuators that act proportionally. It can therefore also be used for familiarizing and training.

You approximate the controlled system to the properties of the real process by selecting the parameters correspondingly. The configuration tool can be used to find a set of suitable controller characteristics through identification of the model system.

Functions of the Example Program

The example Example 355 C essentially comprises the two function blocks PID_FM (FB 31) and PROC_C (FB 100). PID_FM embodies the controller while PROC_C simulates a controlled system with a third-order regulation (refer to the figure below).

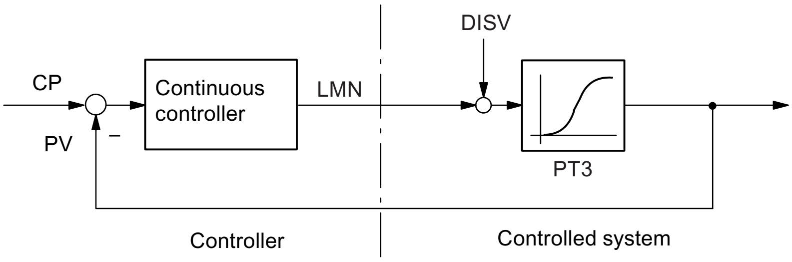


Figure 13-5   Example Example 355 C, control circuit

The PROC_C function block simulates a series connection that consists of three first-order time delays (refer to the following figure). The disturbance variable DISV is always added to the output signal of the actuator so that system disturbances can be fed forward manually at this point. The static system gain can be determined by means of the GAIN factor.

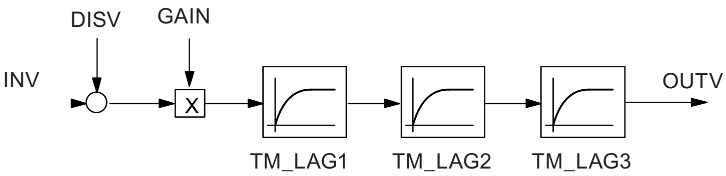


Figure 13-6   Structure and parameters of the controlled system block PROC_C

Block structure

Example 2 consists of the function APP_2, that encompasses the blocks for the controller and the simulated controlled system, as well as of the call blocks for restarting (OB 100) and a watchdog interrupt level (OB 35 with 100 ms cycle).

Table 13-2   Blocks of Example 2

Block	Name (in the toolbar)	Description
OB 100		Restart OB
OB 35		Time-controlled OB 100 ms
FC100	APP_2	Example 2
FC101	SIM_355	Process value transfer in the controller module C
FB 31	PID_FM	Continuous-action controller in the controller module C
FB 100	PROC_C	Controlled system for continuous-action controller
DB 100	PROCESS	Instance DB for PROC_C
DB 31	DB_PID_FM	Instance DB for PID_FM

Parameters of the Model Controlled System for Continuous-Action Controllers

The following figure shows the function scheme and the parameters of the controlled system.

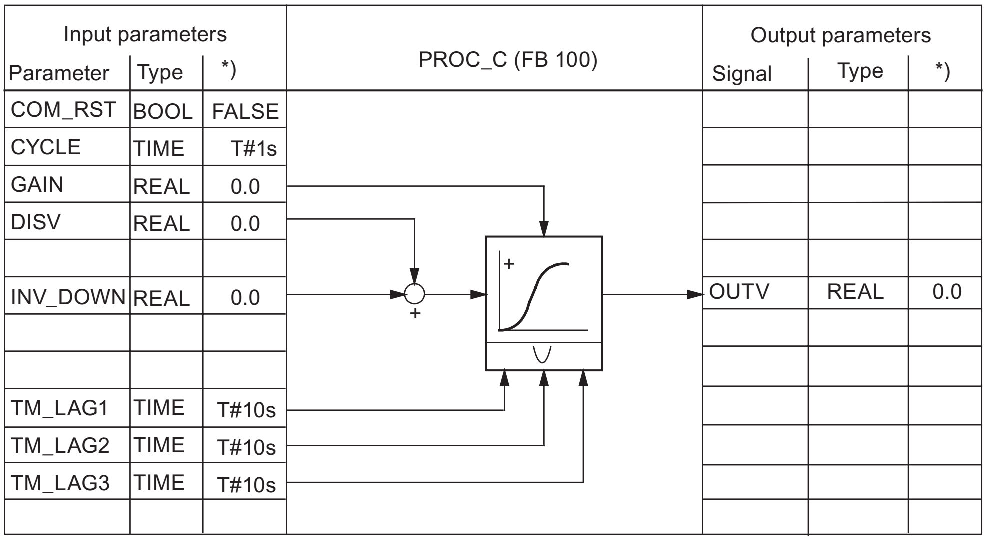


Figure 13-7 Function scheme and parameters of the system model PROC_C

*) Default setting when the instance DB is created

Parameters and Step Response

The reaction of a control loop with simulated PT 3rd-order controlled system is shown by means of a concrete parameter configuration of the continuous-action controller with PID-action. The set system parameters with 10 s delay time each approximately simulate the behavior of a pressure control system or a filling level control system.

Setting one of the delay times to TM_LAGx = 0 s reduces the order of the system by one degree.

The curve diagram (configuration tool) shows the dynamic and transient response of the closed loop circuit after a series of setpoint changes of 20 percent each of the measuring range (refer to the figure below). The table contains the currently set values of the relevant parameters for controller and controlled system.

Parameter	Type	Parameterization	Description
Controller:			
GAIN	REAL	1.535	P-action coefficient
TI	TIME	22.720 s	Integration time
TD	TIME	5.974 s	Derivative time
TM_LAG	TIME	1.195 s	D-action component delay time
Controlled system:			
CYCLE	TIME	100 ms	Sampling time
GAIN	REAL	1.5	Servo gain
TM_LAG1	TIME	10 s	Time lag 1
TM_LAG2	TIME	10 s	Time lag 2
TM_LAG3	TIME	10 s	Time lag 3

Step Response

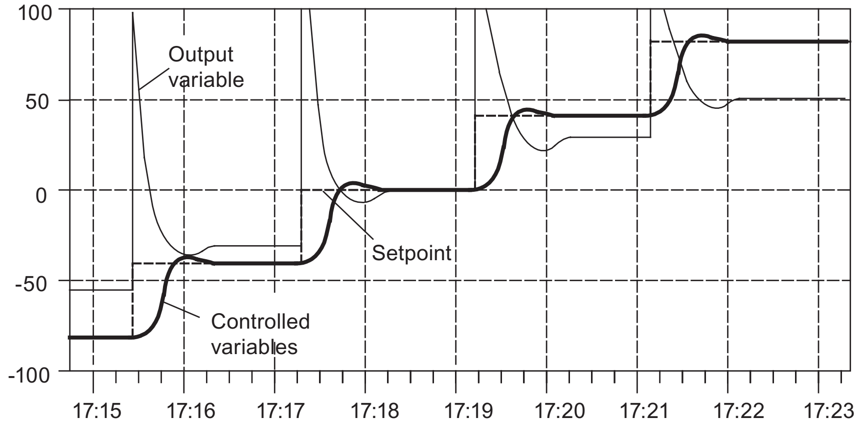


Figure 13-8 Control system with continuous-action controller and setpoint step changes across the entire measuring range

13.3 Application Example for Diagnostics

Introduction

The FM_PIDEx project contains the example "SIMATIC 300 Station3 (C)" that shows you the application and the evaluation of the diagnostics in the DS1 of the controller module.

Prerequisites

Requirements for working with the example:

- CPU 314 is inserted at Slot 2
- FM 355 C is inserted at Slot 4
- CPU and FM 355 C are supplied with power
- Online connection programming device/PC to the CPU exists

If you want to use a different CPU or FM355, you have to adapt the example under the hardware configuration section.

Note

Diagnostic interrupts are only triggered in the CPU if you select the following settings at the "Basic parameters" tab in the "Properties - FM 355 C PID Control" window under HW Config :

- Interrupt generation: Yes
- Interrupt selection: Diagnosis

Loading the Example Program

Download the Blocks user program with the system data to the CPU.

Application of the Example Program

If a diagnostics interrupt occurs, the DIAG_ON parameter of the FB1 FM_DIAG_355 is set in the OB 82. The FM_DIAG_355 is called in the OB 35. It reads the diagnostics record DS1 of the module.

See also

Triggering diagnostic interrupts (Page 12-2)

13.4 Interconnection example for a cascade control

Double loop cascade control

The following figure shows a double loop cascade control:

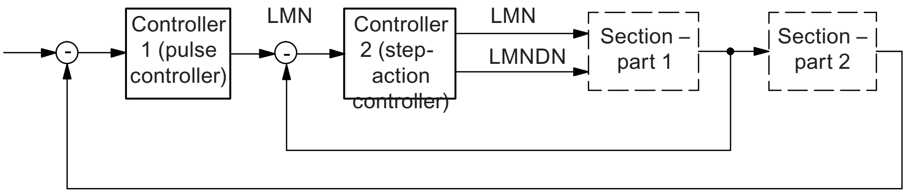


Figure 13-9 Double loop cascade control

You realize this controller interconnection with a controller module S, whereby you configure a pulse controller as the main controller and select the manipulated value of the main controller on the set value input.

You can also realize a controller cascade by means of a controller module C. The main controller is then not a pulse controller and the slave controller is not a step controller. The interconnection must be realized identically.

In the slave controller, the manipulated value of the main controller is standardized from the value range 0 to 100% to the value range of the actual value A and is then further processed as the set value.

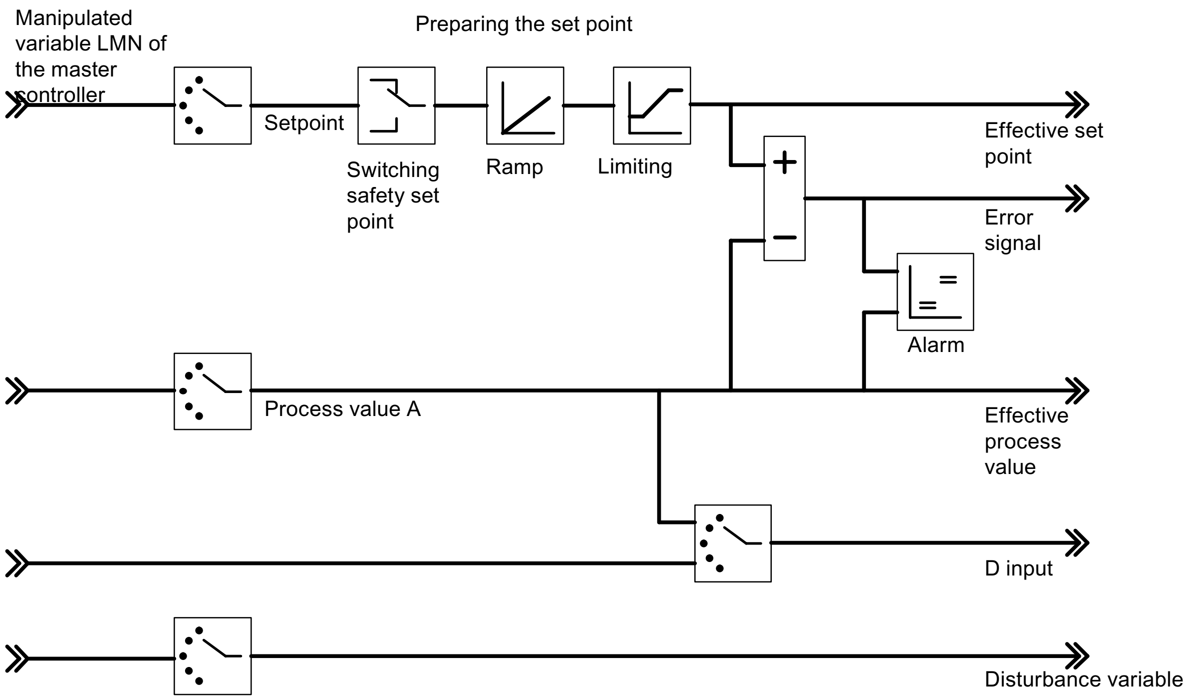


Figure 13-10 Realizing the cascade control with the controller module

13.5 Interconnection example for a ratio control

Ratio controlling with two control circuits

The following figure shows a ratio control with two control circuits:

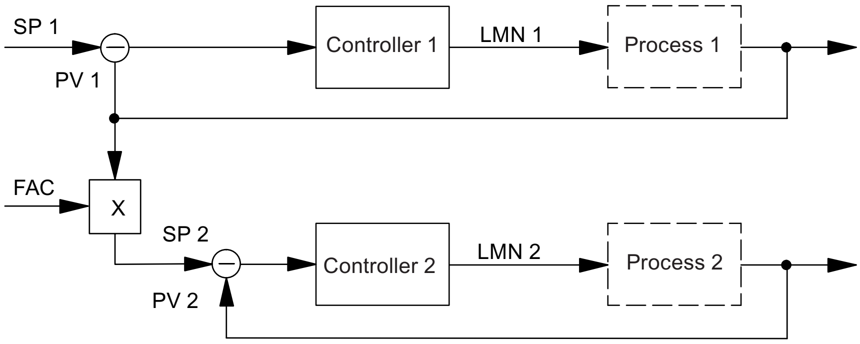


Figure 13-11 Ratio controlling with two control circuits

The controller 1 is configured as the fixed set point controller. Controller 2 is configured as a ratio / mixed controller. The following figure explains its interconnection.

The ratio factor FAC is specified by the set value input of the FB PID_FM (SP_RE or SP_OP).

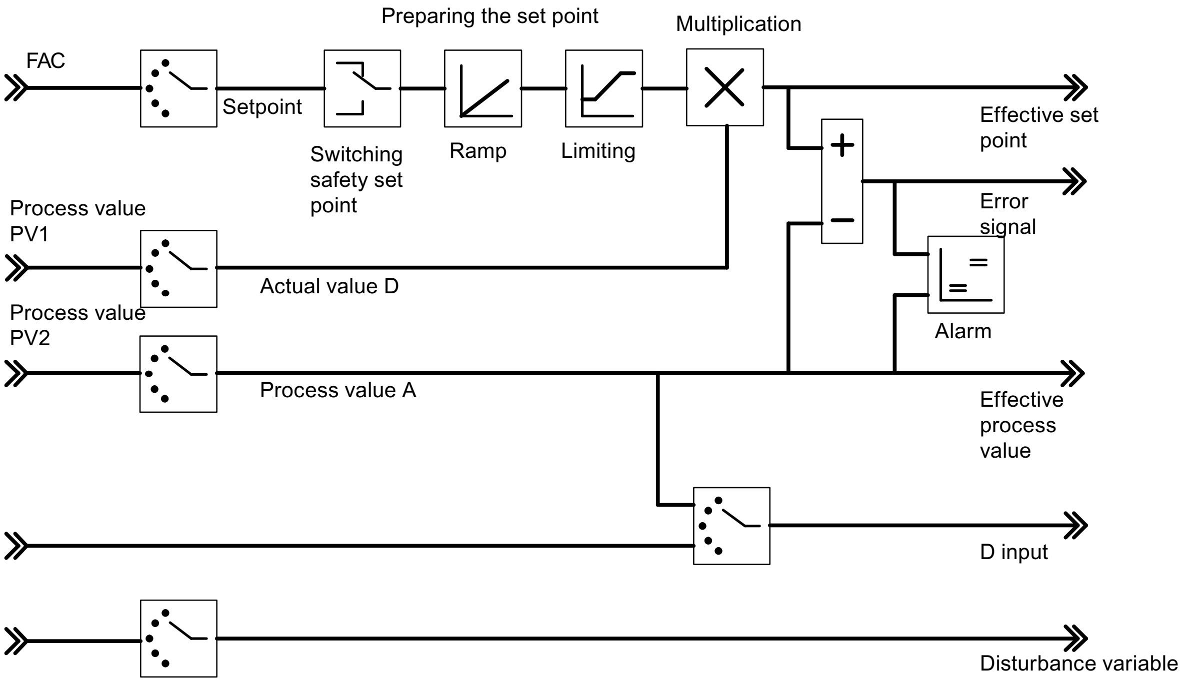


Figure 13-12 Realizing the ratio control with the controller module

13.6 Interconnection example for a mixed control

Mixed controllers for three components

The following figure shows a mixed control for three components:

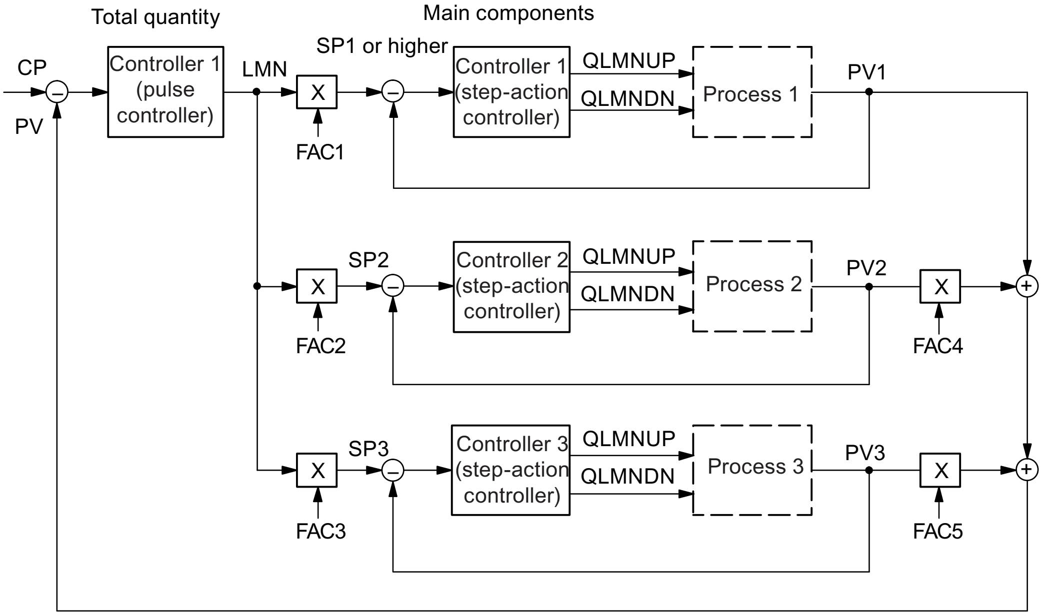


Figure 13-13 Mixed controllers for three components

The main controller is configured as a three-component controller and pulse controller. The controllers 1, 2 and 3 are configured as ratio / mixed controllers. The interconnection for the main controller is shown in the following figure.

You can configure the mixing factors for the components PV2 and PV3 via the "add up" button. If you have to change these factors during runtime, it is possible to do this via the FB PID_PAR.

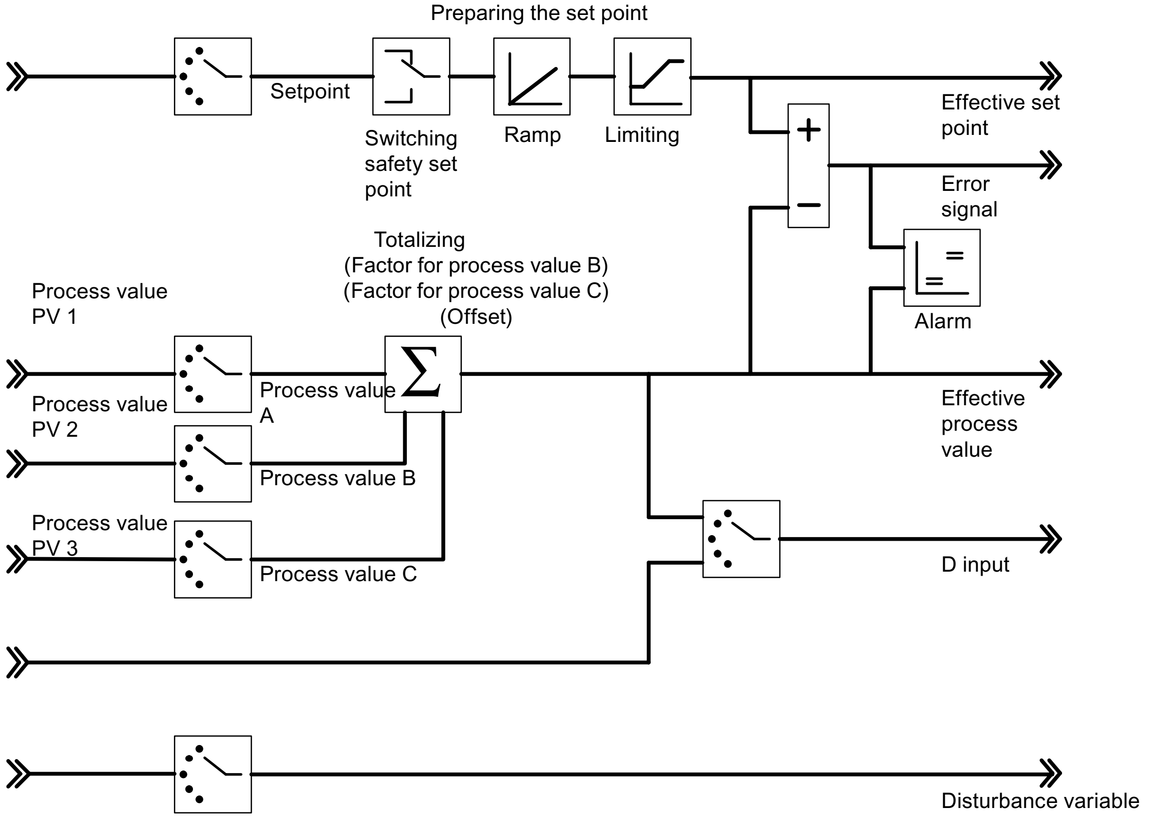


Figure 13-14 Realizing the total amount controller (main controller)

The slave controllers are configured as ratio / mixed controllers. The example of the component PV1 in the figure below shows their interconnection. The mixing factor FAC is specified by the set value input of the FB PID_FM (SP_RE or SP_OP).

In the slave controller (mixed controller), the manipulated variable of the main controller is standardized from the value range 0 to 100% to the value range of the actual value A and is then further processed as the set value D.

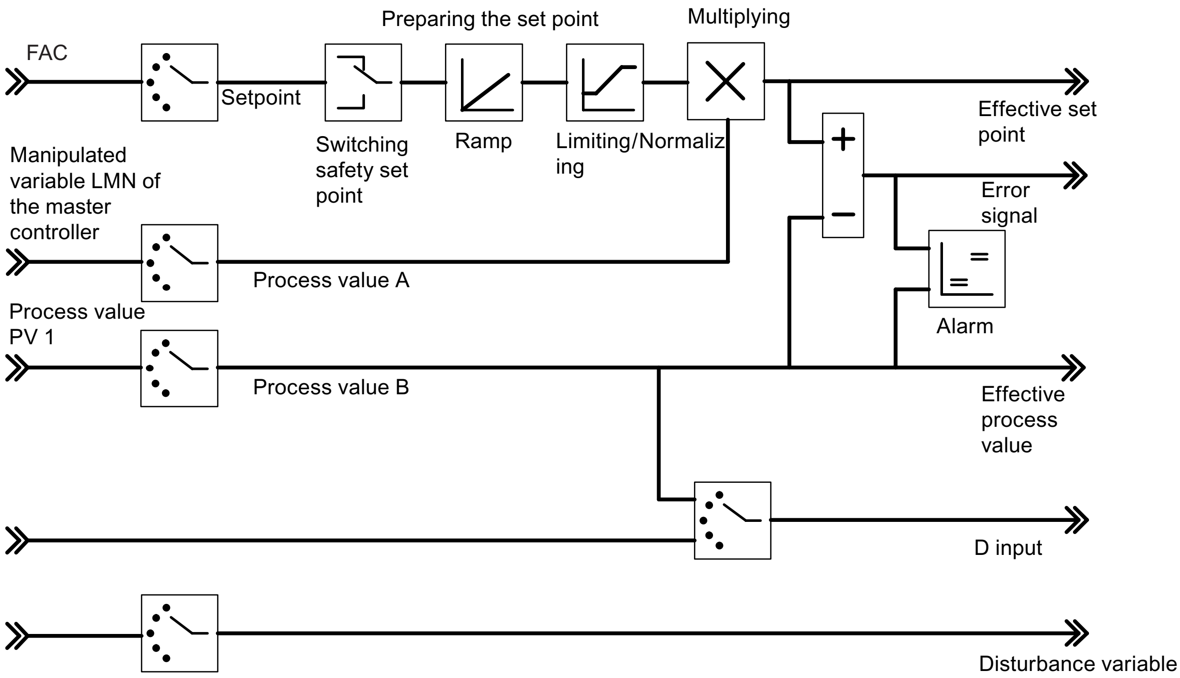


Figure 13-15 Realizing the component controller (slave controller)

See also

Introduction (Page 7-23)

FB 29 and FB 30

A

A.1 The FB 29 "PID_PAR" function block

Use

FB 29 "PID_PAR” is used for online modification of parameters that cannot be specified through FB PID_FM.

The block uses SFC 102 and can therefore only be deployed in the new S7-300 CPU with MMC.

Creating and supplying power to the instance DB

Before you program the module with the user program, you need to create an instance DB for each controller channel you wish to use and supply them with the required data.

1. In STEP 7, create the instance DBs as data blocks with an assigned FB "PID_PAR” function block.
2. For each instance DB enter the module address in the MOD_ADDR parameter. The module address of the FM 355 is determined by the configuration of your hardware. Take the start address from HW Config.
3. Enter the channel number of the corresponding controller channel (1, 2, 3 or 4) in the CHANNEL parameter for each instance DB.
4. Store the instance DBs.

You can also supply the values of MOD_ADDR and CHANNEL when you call up the block.

Start and Initialization

FB 29 "PID_PAR” must be started in the same watchdog OB as all other FBs that access the same FM 355.

FB 29 "PID_PAR" requires an initialization run. it is automatically triggered if the system data (SDB default data of the FM 355) has not yet been read from the FB29 "PID_PAR". You can also start the initialization yourself with COM_RST=TRUE, which is usually done in OB100 since the system data is sent to the FM 355 after STOP-RUN of the CPU. The initialization process lasts several cycles. No data is sent to the FM 355 via SFC 58 during the initialization (COM_RST=TRUE). The block automatically resets the COM_RST parameter after the initialization.

When the FM 355 is used in distributed I/O, it may take several start cycles for the parameters to be completely sent to the FM 355 via SFC 58. The BUSY parameter has the value TRUE as long as the transmission is ongoing. To change the parameters, you should call the block repeatedly over several cycles until BUSY = FALSE and RET_VALU = 0.

To conserve system resources and time, FB 29 "PID_PAR” should be called only when parameters are to be changed and not in every cycle.

Description

FB 29 "PID_PAR” can be used to change one of the REAL parameters and one of the INT parameters listed in the following table each time it is called.

The assignment of the specified value to the parameter is carried out via the index numbers listed in the table, which you can specify in the INDEX_R or INDEX_I parameter in the instance DB of "FB PID_PAR”.

If the input COM_RST = TRUE, the FB reads the parameters from the system data and saves them in static variables. The parameters to be changed are overwritten there and the complete record is then transferred to the FM 355. Since the FB has its own data retention for the parameters in its static variables, additional parameters can also be changed without initialization. To this purpose you must call up the same instance DB several times consecutively with different index numbers. Take into consideration the maximum number write and read requests by SFC 58/59 in the respective CPU.

The output parameter RET_VALU contains the RET_VAL of SFC102 during the initialization. The RET_VAL of SFC 58 is displayed when writing to the FM 355. The values of RET_VAL are described in the reference manual /2/. If the INDEX_R or INDEX_I parameter is outside the allowed range, RET_VALU = W#16#80FF is output. If the CHANNEL parameter is outside its allowed range, RET_VALU = W#16#80B0 is output.

Note

Note that the parameters you change by using FB 29 "PID_PAR” are overwritten by the parameters of the system data when the CPU starts up.

Example

During operation you want to modify the start-up time of the ramp for the reference variable and, depending on the process state, use different analog input values as the process value.

- Set the COM_RST parameter as TRUE in the instance DB in the CPU startup (OB 100).
- To configure the ramp-up time of the ramp for the reference variable to 10.0, call the block with INDEX_R = 30, VALUE_R = 10.0. In the same call, you can also configure analog input value 4 of the module as the process value. Call the block INDEX_I = 50 and VALUE_I = 4 to do this.
- Call the block over several cycles until BUSY = FALSE, RET_VALU = 0 and COM_RST = FALSE.

Modifiable Parameters

Table A-1 List of the REAL and INT parameters that can be changed with the "PID_PAR" FB

Data type	Description	Index number
-	No parameter selected	0
REAL	Filter time constant for the analog input	1
REAL	Measurement end (100%)	2
REAL	Measurement start (0%)	3
REAL	Polyline, interpolation point 1 input side	4
REAL	Polyline, interpolation point 2 input side	5
REAL	Polyline, interpolation point 3 input side	6
REAL	Polyline, interpolation point 4 input side	7
REAL	Polyline, interpolation point 5 input side	8
REAL	Polyline, interpolation point 6 input side	9
REAL	Polyline, interpolation point 7 input side	10
REAL	Polyline, interpolation point 8 input side	11
REAL	Polyline, interpolation point 9 input side	12
REAL	Polyline, interpolation point 10 input side	13
REAL	Polyline, interpolation point 11 input side	14
REAL	Polyline, interpolation point 12 input side	15
REAL	Polyline, interpolation point 13 input side	16
REAL	Polyline, interpolation point 1 output side	17
REAL	Polyline, interpolation point 2 output side	18
REAL	Polyline, interpolation point 3 output side	19
REAL	Polyline, interpolation point 4 output side	20
REAL	Polyline, interpolation point 5 output side	21
REAL	Polyline, interpolation point 6 output side	22
REAL	Polyline, interpolation point 7 output side	23
REAL	Polyline, interpolation point 8 output side	24
REAL	Polyline, interpolation point 9 output side	25
REAL	Polyline, interpolation point 10 output side	26
REAL	Polyline, interpolation point 11 output side	27

Data type	Description	Index number
REAL	Polyline, interpolation point 12 output side	28
REAL	Polyline, interpolation point 13 output side	29
REAL	Start-up time of the ramp for the reference variable	30
REAL	Safety reference variable or safety reference variable response	31
REAL	Offset for setpoint link (ratio/mixing controller)	32
REAL	Factor for process value B (three component controller)	33
REAL	Factor for process value C (three component controller)	34
REAL	Offset for process value link (three component controller)	35
REAL	Factor for disturbance variable link	36
REAL	Operating point	37
REAL	Aggressivity at fuzzy controller	38
REAL	Vertices for split range function: Start of input signal A range	39
REAL	Vertices for split range function: End of input signal A range	40
REAL	Vertices for split range function: Start of output signal A range	41
REAL	Vertices for split range function: End of output signal A range	42
REAL	Vertices for split range function: Start of input signal B range	43
REAL	Vertices for split range function: End of input signal B range	44
REAL	Vertices for split range function: Start of output signal B range	45
REAL	Vertices for split range function: End of output signal B range	46
REAL	Minimum pulse time	47
REAL	Minimum pulse time	48
INT	Choice of reference variable SP or SP_RE for the controller 0: Setpoint SP_RE of the function block 1 to 4: Analog input value 1 to 4 17 to 20: Manipulated variable (LMN) of controllers 1 to 4	49
INT	Selection of the main control variable process value A for the controller 0: Process value A = 0.0 1 to 4: Analog input value 1 to 4	50

Data type	Description	Index number
INT	Selection of the auxiliary control variable process value B for the controller 0: Process value B = 0.0 1 to 4: Analog input value 1 to 4	51
INT	Selection of the auxiliary control variable process value C for the controller 0: Process value C = 0.0 1 to 4: Analog input value 1 to 4	52
INT	Selection of the auxiliary control variable process value C for the controller 0: Process value D = 0.0 1 to 4: Analog input value 1 to 4 17 to 20: Manipulated variable (LMN) of controllers 1 to 4	53
INT	Selection of the DISV disturbance variable for the controller 0: Disturbance variable = 0.0 1 to 4: Analog input value 1 to 4	54
INT	Selection of the position tracking TRACK_PER for the controller 0: Position adjustment = 0.0 1 to 4: Analog input value 1 to 4	55
INT	Selection of the position tracking LMNR_PER for the controller 0: Position adjustment = 0.0 1 to 4: Analog input value 1 to 4	56
INT	Selection of the signal for switching to the safety value for the manipulated varaible of the controller 0: Selected only via SAFE_ON parameter of FB PID_FM 1 to 8: Selection via SAFE_ON parameter of FB PID_FM ORed with digital input 1 to 8	57
INT	Selecting the signal for switching over to tracking function of the manipulated variable of the controller 0: Selected only via LMNTRKON parameter of FB PID_FM 1 to 8: Selection via LMNTRKON parameter of FB PID_FM ORed with digital input 1 to 8	58

Data type	Description	Index number
INT	Selecting the signal for switching over the manipulated variable of the controller to LMN_RE 0: Selected only via LMN_REON parameter of FB PID_FM 1 to 8: Selection via LMN_REON parameter of FB PID_FM ORed with digital input 1 to 8	59
INT	Selection of the upper stop signal of the position feedback 0: Selected only via LMNRHSRE parameter of FB PID_FM 1 to 8: Selection via LMNRHSRE parameter of FB PID_FM ORed with digital input 1 to 8	60
INT	Selection of the lower stop signal of the position feedback 0: Selected only via LMNRLSRE parameter of FB PID_FM 1 to 8: Selection via LMNRLSRE parameter of FB PID_FM ORed with digital input 1 to 8	61

A.2 Instance DB of the FB 29

Introduction

The parameters of the instance DB are listed in the following tables:

- Input parameters
- Output parameters
- Through parameters

Input parameters

Table A-2 Input parameters of the instance DB for the FB 29 "'PID_PAR"

Address	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assignment screen form
0.0	MOD_ADDR	INT	FM 355 module address FM 355 module address		256	The module address that resulted from the configuration with STEP 7 is given at this input.	-
2.0	CHANNEL	INT	Channel number 1 to 4 Channel number 1..4	1 to 4	1	The number of the controller channel to which the instance DB is referenced is configured at input "Channel number".	-
4.0	INDEX_R	INT	Index for REAL parameter Index for REAL parameter	0 to 48	0.0	Refer to the section "The PID_PAR Function Block"	-
6.0	VALUE_R	REAL	value for REAL parameter value for REAL parameter	depending on respective parameter	0.0	Refer to the section "The PID_PAR Function Block"	-
10.0	INDEX_I	INT	Index for INT parameter Index for INT parameter	0. 49 to 61	0.0	Refer to the section "The PID_PAR Function Block"	-
12.0	VALUE_I	INT	Value for INT parameter Value for INT parameter	depending on respective parameter	0.0	Refer to the section "The PID_PAR Function Block"	-

Output parameters

Table A-3 Input parameters of the instance DB for the FB 29 "'PID_PAR"

Address	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assignment screen form
14.0	RET_VALU	WORD	Return value of SFC 58 and SFC 102 Return value of SFC 58 and SFC 102		0	RET_VALU contains the return value RET_VAL of the SFC58 for COM_RST=FALSE and SFC 102 for COM_RST=TRUE.. RET_VALU=W#16#80FF if INDEX_R or INDEX_I are not within permitted value range. RET_VALU=W#16#80B0 if CHANNEL is not within permitted value range.	-
16.0	BUSY	BOOL	BUSY value of SFC 58 and SFC 102 BUSY display of the SFC 58 and SFC 102		FALSE	BUSY contains the return value BUSY of the SFC 58 for COM_RST=FALSE and SFC 102 for COM_RST=TRUE. If BUSY = TRUE, the parameters have not yet been entered in the module (for distributed I/Os). FB PID_PAR should then be called again in the next cycle taking RET_VALU into account.	-

Through parameters

Table A-4 Through parameters of the instance DB for the FB 29 "'PID_PAR"

Address	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the para meter assignment screen
18.0	COM_RST	BOOL	read parameters from system data Read parameters from system data		TRUE	If the parameter COM_RST = TRUE, the FB PID_PAR performs an initialization. The parameters are read from the system data of the CPU and saved in the instance DB. The block sets COM_RST automatically. The user usually sets COM_RST to TRUE in OB100.	

A.3 The FB 30 "CJ_T_PAR" function block

Use

The FB 30 "CJ_T_PAR" is used for online modification of the configured reference junction temperature. This is required when a temperature control system with several FM 355s with thermoelement inputs is operated without connecting a Pt 100 to each FM 355.

If, for example, the reference junction temperature is measured with an FM 355 at an extruder control system with more than four heating zones, this can be read out via READ_355 FB at the CJ_TEMP parameter and configured at the other FM 355 units via the FB 30 "CJ_T_PAR".

Creating and supplying power to the instance DB

Before you program the module with the user program, you need to create an instance DB and supply it with the required data.

1. Use STEP 7 to create the instance DB as data blocks with an assigned FB 30 "CJ_T_PAR" function block.
2. Enter the module address in the MOD_ADDR parameter for the instance DB. The module address of the FM 355 is determined by the configuration of your hardware. Take the start address from HW Config.
3. Save the instance DB.

The reference junction temperature can be specified via the CJ_T parameter.

The RET_VALU output value contains the return value RET_VAL of the SFC58 for COM_RST=FALSE and SFC 102 for COM_RST=TRUE.

Start and Initialization

The FB 30 "CJ_T_PAR" must be called in the same OB as all the other FBs that access the same FM 355.

The FB 30 "CJ_T_PAR" requires an initialization run. it is automatically triggered if the system data (SDB default data of the FM 355) has not yet been read from the FB 30 "CJ_T_PAR". You can also start the initialization yourself with COM_RST=TRUE, which is usually done in OB100 since the system data is sent to the FM 355 after STOP-RUN of the CPU. The initialization process lasts several cycles. No data is sent to the FM 355 via SFC 58 during the initialization (COM_RST=TRUE). The block automatically resets the COM_RST parameter after the initialization.

The FB 30 "CJ_T_PAR" is usually called cyclically. When the FM 355 is used in distributed I/O, it may take several start cycles for the parameters to be completely sent to the FM 355 via SFC 58. The BUSY parameter has the value TRUE as long as the transmission is ongoing and RET_VALU is does not equal zero. Changes in the reference temperature are not transmitted during this period. The internal sampling time of the FM 355 must also be taken into consideration here.

Note

Note

Note that the reference junction temperature you change by using FB 30 "CJ_T_PAR" is overwritten by the parameters of the system data when the CPU starts up.

A.4 Instance DB of the FB 30

Introduction

The parameters of the instance DB are listed in the following tables:

- Input parameters
- Output parameters
- Through parameters

Input parameters

Table A-5 Input parameters of the instance DB for the FB 30 "CJ_T_PAR"

Address	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assignment screen form
0.0	MOD_ADDR	INT	FM 355/455 module address		256	The module address that resulted from the configuration with STEP 7 is given at this input.	-
2.0	CJ_T	REAL	Cold junction temperature	depending on sensor type	0.0	The reference junction temperature can be specified via the CJ_T parameter.	-

Output parameters

Table A-6 Output parameters of the instance DB for the FB 30 "CJ_T_PAR"

Address	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assignment screen form
6.0	RET_VALU	WORD	return value SFC 58/59		0	RET_VALU contains the return value RET_VAL of the SFC58 for COM_RST=FALSE and SFC 102 for COM_RST=TRUE..	-
8.0	BUSY	BOOL	BUSY value of SFC WR_REC		FALSE	BUSY contains the return value BUSY of the SFC 58 for COM_RST=FALSE and SFC 102 for COM_RST=TRUE. If BUSY = TRUE, the parameters have not yet been entered in the module (for distributed I/Os). The FB PID_PAR should then be called again in the next cycle taking RET_VALU into account (with distributed I/O). The FB PID_PAR should then be called again in the next cycle.	-

Through parameters

Table A-7 Through parameters of the instance DB for the FB 30 "CJ_T_PAR"

Address	Parameter	Data type	Comment English	Permitted range of values	Default setting	Explanation	In the parameter assignment screen form
10.0	COM_RST	BOOL	read parameters from system data		-	If the parameter COM_RST = TRUE, the FB PID_PAR performs an initialization. The parameters are read from the system data of the CPU and saved in the instance DB. The block sets COM_RST automatically. COM_RST is usually set to TRUE in OB100 by the user.	-

A.5 List of RET_VALU messages

RET_VALU messages

JOB_ERR (Hex)	JOB_ERR (Dec)	JOB_ERR (Int)	Meaning
7000	28672	-32624	First call with REQ=0: no data transmission active; BUSY has the value 0.
7001	28673	-32624	First call with REQ=1: data transmission initiated; BUSY has the value 1.
7002	28674	-32624	Interim call (REQ irrelevant). Data transmission already active; BUSY has the value 1.
8090	32912	-32624	Specified logical base address invalid: There is no assignment in the SDB1/SDB2x, or it is not a base address.
80A0	32928	-32608	Negative acknowledgment when reading from the module. Module was removed during the read operation or the module is defective.
80A1	32929	-32607	Negative acknowledgment when writing to the module. Module was removed during the write operation or the module is defective.
80A2	32930	-32606	DP protocol error at layer 2
80A3	32931	-32605	DP protocol error in user interface/user
80A4	32932	-32604	Communication bus error
80B1	32945	-32591	Incorrect length specification. FM_TYPE parameter in channel DB not set correctly for the module in use.
80B2	32946	-32590	The configured slot is not being used.
80B3	32947	-32589	Actual module type is not match configured module type.
80C0	32960	-32576	Module data not ready for reading.
80C1	32961	-32575	Data of a write job of the same type have not yet been processed by the module.
80C2	32962	-32574	The module is currently processing the maximum possible number of jobs.
80C3	32963	-32573	Required resources (memory etc.) currently occupied.
80C4	32964	-32572	Communication error
80C5	32965	-32571	Distributed I/O not available.
80C6	32966	-32570	Priority class abort (restart or background).
8522	34082	-31454	Channel DB or parameter DB too short. The data cannot be read off the DB. (Write job)
8532	34098	-31438	DB number of the parameter DBs too high. (Write job)
853A	34106	-31430	Parameter DB not present. (Write job)
8544	34116	-31420	Error at n-th (n > 1) read access to a DB after an error has occurred. (Write job)
8723	34595	-30941	Channel DB or parameter DB too short. The data cannot be written to the DB. (Read job)
8730	34608	-30928	Parameter DB in the CPU is write protected. The data cannot be written to the DB (read job)
8732	34610	-30926	DB number of the parameter DBs too high (Read job)

JOB_ERR (Hex)	JOB_ERR (Dec)	JOB_ERR (Int)	Meaning
873A	34618	-30918	Parameter DB not present. (Read job)
8745	34629	-30907	Error at n-th (n > 1) write access to a DB after an error has occurred. (Read job)
80ff	33023	-32513	Incorrect index specification with block FMT_PAR
Errors 80A2..80A4 and 80Cx are temporary, i.e. after a waiting period they can be eliminated without any action on your part. Messages of the 7xxx form indicate temporary operating states of communication.			

Data Sheet B

B.1 Technical Specifications S7-300

General technical specifications

General technical specifications are

- Electromagnetic compatibility
- Shipping and storage conditions
- Mechanical and climatic environmental conditions
- Specifications for insulation tests, protection class and degree of protection

These general technical specifications are explained in Manual /1/. They contain standards and test values that the S7-300 fulfils and the criteria used to test the S7-300.

Approbations

The S7-300 has the following approvals:

UL Recognition Mark
Underwriters Laboratories (UL) in accordance with Standard UL 508

CSA-Certification-Mark
Canadian Standard Association (CSA) to Standard C22.2 No. 142

FM approval complying with Factory Mutual Approval Standard Class Number 3611, Class I, Division 2, Group A, B, C, D

Warning

Personal injury and material damage may be incurred.

In potentially explosive environments, there is a risk of injury or damage if you disconnect any connectors while the S7-300 is in operation.

Always isolate the S7-300 operated in such areas before you disconnect and connectors.

Warning

DO NOT DISCONNECT WHILE CIRCUIT IS LIVE UNLESS LOCATION IS KNOWN TO BE NONHAZARDOUS

CE Marking

Our products fulfill the requirements of the EU Directive 89/336/EEC ”Electromagnetic compatibility”.

The EU conformity certificates are available for the relevant authorities and are kept at the following address in accordance with the above-mentioned EU Directive. Article 10:

Siemens Aktiengesellschaft
Bereich Automatisierungs- und Antriebstechnik
A&D AS RD ST PLC
Postfach 1963
D-92209 Amberg

Area of Application

SIMATIC products are designed for use in industrial environments.

SIMATIC products may be also used in combination with an individual license in residential areas (residential, commercial and industrial areas, small enterprises).

Area of application	Requirements in respect of	
	Emitted interference	Interference immunity
Industry	EN 50081-2 : 1993	EN 50082-2 : 1995

Observe the Installation Guidelines

SIMATIC products fulfill the requirement if you observe the installation guidelines described in the manuals during installation and operation.

B.2 Technical Specifications FM 355

Technical Specifications of the FM 355

Dimensions and Weight	
Dimensions W x H x D (mm) Weight	 80 x 125 x 120 Approx. 470 g
Module-Specific Data	
Number of digital inputs Number of digital outputs Number of analog inputs Number of analog outputs Length of cable • Digital signals unshielded • Digital signals shielded • Analog signals shielded	8 8 (only step controller) 4 4 (only continuous-action controller) Max. 600 m Max. 1000 m 200 m 50 m at 80 mV and thermocouples
Voltages, Currents, Potentials	
Rated load voltage L+ • Permitted range • Polarity reversal protection for input supply • Polarity reversal protection for output supply	24 V DC 20.4 to 28.8 V Yes Yes
Number of digital inputs that can be triggered simultaneously • Horizontal mounting up to 60°C • Vertical mounting up to 40°C	 8 8
Total current of the digital outputs • Horizontal mounting up to 40°C up to 60°C • Vertical mounting up to 40°C	 max. 0.4 A max. 0.4 A max. 0.4 A
Electrical isolation • To the backplane bus • Between the channels	 Yes (optocoupler) No
Permissible potential difference • Between input (M terminal) and central grounding point • Between the analog inputs and M_{ANA} (U_{CM}) – At signal = 0 V • Insulation tested with	 75 V DC, 60 V AC 2.5 V DC 500 V DC

Current consumption • From the backplane bus • From L+ (no load) – Continuous-action controller – Step controller	 Typ. 50 mA, max. 75 mA Typ. 260 mA, max. 310 mA Typ. 220 mA, max. 270 mA
Power dissipation of the module • Continuous-action controller • Step controller	 typ. 6.5 W, max. 7.8 W typ. 5.5 W, max. 6.9 W
Status, Interrupts, Diagnostics	
Status display	Yes, green LED per digital input channel
Interrupts • Limit value interrupt • Diagnostics interrupt	 yes, configurable yes, configurable
Diagnostic functions • Fault indication on the module in the event of a group fault • Reading diagnostic information	Yes, configurable Yes, red LED Yes
Backup operation	Yes display through yellow LED
Interference Suppression, Error Limits (Inputs)	
Interference voltage suppression for f = n x (f1 ± 1 %), (f1 = interference frequency) • Common-mode noise (V_{pp} < 2.5 V) • Series-mode interference (peak value of disturbance < rated input range)	 > 70 dB > 40 dB
Crosstalk between the inputs • At 50 Hz • At 60 Hz	 50 dB 50 dB
Operational error limits (across the temperature range, referenced to the input range) • 80 mV • 250 mV to 1000 mV • From 2.5 V to 10 V • 3.2 mA to 20 mA	 ± 1 % ± 0,6 % ± 0,8 % ± 0,7 %
Basic error limit (operational limit at 25°C, referenced to input range) • 80 mV • 250 mV to 1000 mV • From 2.5 V to 10 V • 3.2 mA to 20 mA	 ± 0,6 % ± 0,4 % ± 0,6 % ± 0,5 %
Temperature error (referenced to the input range)	±0.005%/K
Linearity error (referenced to the input range)	± 0,05 %
Repeat accuracy (in transient state at 25°C, referenced to input range)	± 0,05 %

Interference Suppression, Error Limits (Outputs)		
Crosstalk between the outputs	40 dB	
Operational error limit (in the entire temperature range, referenced to the output range) • Voltage • Current	 ± 0,5 % ± 0,6 %	
Basic error limit (operational limit at 25°C, referenced to output range) • Voltage • Current	 ± 0,4 % ± 0,5 %	
Temperature error (referenced to output range)	± 0.02 %/K	
Linearity error (referenced to output range)	± 0,05 %	
Repeat accuracy (in transient state at 25°C, referenced to output range)	± 0,05 %	
Output ripple; range 0 kHz to 50 kHz (referenced to output range)	± 0,05 %	
Data for Selecting a Sensor (Digital Inputs)		
Input voltage • Rated value • For signal "1" • For signal "0"	 DC 24 V from 13 to 30 V from –3 to 5 V	
Input current • At signal "1"	 Typ. 7 mA	
Input delay time • Configurable • At "0" to "1" • At "1" to "0"	 no from 1.2 to 4.8 ms from 1.2 to 4.8 ms	
Input characteristics	To IEC 1131, Type 2	
Connection of 2-wire BEROs • Permissible quiescent current	Possible ≤ 1.5 mA	
Data for Selecting a Sensor (Analog Inputs)		
Input ranges rated values (display range) / input impedance		
• Voltage **	± 80 mV (–80 to +80 mV)*** 0 to 10 V (–1.175 to 11.75 V)	/10 MΩ /100 kΩ
• Current **	0 to 20 mA (–3.5 to 23.5mA) 4 to 20 mA (0 to 23.5 mA)	/50 Ω * /50 Ω *
• Thermocouple type **	B (0 to 13.81 mV) [42.15°C to 1820.01°C] J (-8.1 to 69.54 mV) [–210.02°C to 1200.02°C] K (–6.45 to 54.88 mV) [–265.40°C to 1372.11°C] R (–0.23 to 21.11 mV) [–51.37°C to 1767.77°C] S (–0.24 to 18.7 mV) [–50.40°C to 1767.98°C]	/10 MΩ /10 MΩ /10 MΩ /10 MΩ /10 MΩ

• Resistance thermometer **	Pt 100, current 1.667 mA pulsed: (30,82 ... 650.46 mV) –200.01 ... 850.05 °C (single resolution) (30,82 ... 499.06 mV) –200.01°C to 556.26°C (double resolution) (30,82 ... 254.12 mV) –200.01°C to 129.20°C (fourfold resolution)	/10 MΩ

* External measuring resistor

** The same limits apply for underflow and overflow indication as for the indication range. Exception: Underflow indication at 4 to 20 mA: 1 at < 3.6 mA; 0 at > 3.8 mA. In the case of a wire break the underflow display shows between 4 and 20 mA.

*** Or the lower or upper input value respectively of the polygon. The lower value applies.

Further data for selecting a sensor (analog inputs)	
Permissible input voltage for voltage input (destruction limit)	30 V (for a maximum of 2 inputs)
Permissible input current at current input (destruction limit)	40 mA
Connection of signal sensors • For voltage measurement • For current measurement as four-wire measuring transducers	 Possible Possible
Characteristics linearization • For thermocouples • For thermoresistors	Yes, configurable Type B, J, K, R, S Pt 100 (standard range)
Temperature compensation • Internal temperature compensation • External temperature compensation with Pt 100	Yes, configurable Possible Possible
Data for Selecting an Actuator (Digital Outputs)	
Output voltage • At signal "1"	 Min. L+ (–2.5 V)
Output current • Rated value at Signal "1" permissible range • Leakage current at "0" signal	 0.1 A From 5 mA to 0.15 A Max. 0.5 mA
Load impedance range	240 Ω to 4 kΩ
Output power • Lamp load	 Max. 5 W
Connection in parallel of two outputs • For logic operation • For performance increase	 Possible not possible
Controlling of a digital input	Possible

Further data for selecting a sensor (analog inputs)			
Switching frequency • At resistive load/lamp load • At inductive load	Max. 100 Hz Max. 0.5 Hz		
Internal limiting of the inductive shutdown voltage to	Typ. L+ (–1.5 V)		
Short-circuit protection of the output	Yes, electronic		
Actuator selection data (Digital outputs)			
Output ranges (Rated values)	± 10 V from 0 to 10 V from 0 to 20 mA from 4 to 20 mA		
Load resistance • At voltage outputs – Capacitive load • At current outputs – Inductive load	min. 1 kΩ max. 1 µF max. 500 Ω max. 1 mH		
Voltage output • Short-circuit protection • Short-circuit current	Yes Max. 25 mA		
Current output • Open-circuit voltage	Max. 18 V		
Connection of actuators • At voltage output with 2-wire connection • At current output with 2-wire connection	Possible Possible		
Analog Value Generation			
Measuring principle Resolution (incl. overrange)	Integrating Configurable: 12 bits 14 bits		
Conversion time (per analog input) • At 12 bits resolution • At 12 bits resolution • At 14 bits resolution	16 $^{2}/_{3}$ ms (at 60 Hz) 20 ms (at 50 Hz) 100 ms (at 50 and 60 Hz)		
Settling time • For resistive load • For capacitive load • For inductive load	0.2 ms 3.3 ms 0.5 ms		
Input of substitution values	Yes, configurable		
Time per channel	Integration time	Conversion time	Resolution
• Configurable			
• Integration time	16$^{2}/_{3}$ ms	20 ms	100 ms
• Basic conversion time incl. processing time	17 ms	22 ms	102 ms
• Additional conversion time for resistance measurement	1 ms	1 ms	1 ms
• Additional conversion time for reference junction input	16$^{2}/_{3}$ ms	20 ms	100 * ms

Further data for selecting a sensor (analog inputs)			
• Resolution in bits (including overshoot range) measuring range	12	12	14
• Interference voltage suppression at interference frequency f1 in Hz	60	50	50, 60
* Applies if a resolution of 14 bits is configured at at least one input.			

B.3 Technical Specifications of Function Blocks

Technical Specifications of the Function Blocks

Table B-1 Technical specifications of the function blocks

Function blocks	Assignment in			Processing time in	
	RAM	Load memory	Local data area	CPU 314	CPU 414
PID_FM	1592 bytes	1976 bytes	40 bytes	Refer to following table	
FORCE355	630 bytes	790 bytes	52 bytes	2.2 ms	2.0 ms
READ_355	526 bytes	644 bytes	66 bytes	2.5 ms	2.2 ms
CH_DIAG	302 bytes	420 bytes	64 bytes	2.3 ms	2.1 ms
FUZ_355	356 bytes	464 bytes	22 bytes	2.1 ms	1.9 ms
PID_PAR	918 bytes	1074 bytes	24 bytes	4.3 to 8 ms	3.8 to 7.2 ms
				Depending on whether INDEX_R and INDEX_I are both ≠ 0	
CJ_T_PAR	274 bytes	354 bytes	22 bytes	1.8 ms	1.6 ms

Table B-2 Processing times of the PID_FM at various conditions

Conditions			Processing time in	
READ_VAR	LOAD_OP	LOAD_PAR	CPU 314	CPU 414-2 DP
FALSE	FALSE	FALSE	0.65 ms	0.077 ms
TRUE	FALSE	FALSE	2.85 ms	2.36 ms
*)	TRUE	FALSE	4.56 ms	4.48 ms
FALSE	FALSE	TRUE	3.75 ms	2.59 ms
TRUE	FALSE	TRUE	5.95 ms	5.15 ms
*)	TRUE	TRUE	7.66 ms	7.1 ms
*) If LOAD_OP = TRUE, READ_VAR is also set to TRUE by the PID_FM FB.				

Table B-3 Technical specifications of the instance DBs

Instance DBs of the function blocks ...	Assignment in	
	RAM	Load memory
PID_FM	190 bytes	490 bytes
FORCE355	64 bytes	214 bytes
READ_355	78 bytes	184 bytes
CH_DIAG	72 bytes	178 bytes
FUZ_355	80 bytes	172 bytes
PID_PAR	290 bytes	410 bytes
CJ_T_PAR	58 bytes	130 bytes

B.4 Technical Data of Parameter Configuration Interface

Parameter Configuration Interface

Technical specifications	Parameter configuration interface
Required memory (hard disk)	4 Mbytes

Technical specifications	System data
Required memory in the CPU	1258 bytes

Spare Parts C

C.1 Spare Parts

Spare Parts

The following table lists all spare parts of the S7-300 that you can order for the FM 355 either additionally or later.

Table C-1 Accessories and spare parts

S7-300 parts	Order No.:
Bus connector	6ES7 390-0AA00-0AA0
Label sheet	6ES7 392-2XX00-0AA0
Slot number label	6ES7 912-0AA00-0AA0
Screw-type front connector (20-pin)	6ES7 392-1AJ00-0AA0
Shield contact element (with 2 screw-type bolts)	6ES7 390-5AA00-0AA0
Shield terminals for	
• 2 cables, each with a shield diameter of 2 to 6 mm	6ES7 390-5AB00-0AA0
• 1 cable with a shield diameter of 3 to 8 mm	6ES7 390-5BA00-0AA0
• 1 cable with a shield diameter of 4 to 13 mm	6ES7 390-5CA00-0AA0

References

D

D.1 References

Supplementary References

The table below lists all the manuals referred to in this manual.

No.	Title	Order No.:
/1/	SIMATIC S7; S7-300 Programmable Controller; Hardware and Installation	6ES7 398-8AA03-8AA0
/2/	SIMATIC; System Software for S7-300 and S7-400 System and Standard Functions	Belongs to Package 6ES7 810-4CA04-8AR0

Basics

The basics of control technology can be found, for example, in the following books:

Title	Author	Order No.:
"Vom Prozeß zur Regelung" (From a process to a control system)	Gißler/Schmid	A19100-L531-F196 ISBN 3-8009-1551-0
"Regeln mit SIMATIC S5 Grundlagen" (Basic principles of controlling with SIMATIC S5)	Siemens	E80850-C331-X-A2

Glossary

Cascade control

The cascade control is a consecutive switching of controllers, whereupon the first controller (master controller) specifies the setpoint for the series-connected controllers (secondary controllers) or influences the setpoints in accordance with the current negative deviation of the main control variable.

By involving additional process variables, the controller result can be improved by using a cascade control. To do this, at a suitable point an auxiliary control variable PV2 is recorded and this controls the reference setpoint (output of the master controller SP2). The master controller controls the process value PV1 on the fixed setpoint SP1 and adjusts the SP2 in such a way that this objective is achieved as quickly as possible, and without overshooting.

Configuration

Tool (software) for creating and configuring a control as well as for optimizing the controller with the aid of the data gained from a section identification.

Control device

Totality of the controller, control device and detector (measuring device) for the control variable.

A control device is the part of the control circuit that serves to influence the control variable on the process input. Usually consists of the association of the control drive and actuator.

Control device

Totality of the controller, control device and detector (measuring device) for the control variable.

A control device is the part of the control circuit that serves to influence the control variable on the process input. Usually consists of the association of the control drive and actuator.

Control loop

With the control loop you describe a connection of the section output (control variable) with the controller input and the controller output (manipulated variable) with the process input, so that the controller and process form a closed loop.

Control variable

Process variable (output variable of the control section) that is to be compared to the current value of the reference variable. Your current value is called the process value.

Controlled system

With a controlled system we describe the part of the unit in which the control variable is influenced by the manipulated variable (by changing the control energy or the flow dimension). This enables subdivisions in the control device and the influenced process.

Controller

A controller is a device that constantly records the negative deviation (comparer) and, if necessary generates a time-dependent function to form the control signal (output variable) with the objective of iradicating the negative deviation as quickly as possible and without overshooting.

Controller parameters

Controller parameters are parameters for the static and dynamic adaptation of the controller behavior to the given section or process properties.

D part (derivative component)

The D part is the derivative component of the controller. D elements alone are unsuitable for controlling, as they do not issue an output signal when setting the input variables to a stead value.

Dead time

Dead time is the time delay for the control variable reaction to disturbances or changes to the manipulated variable for transportation processes. The input variable of a dead time element is set to the value of the dead time 1 : 1 is issued on the output.

Digital control (sample controlling) (digital control)

Controller that records a new value for the control variable (process value) at constant intervals 〈→ sampling time, and then, in dependence on the actual negative deviation, calculates a new value for the manipulated variable.

Disturbance variable

All influence variables on the control variable - with the exception of the manipulated variable - are called disturbance variables. Additive influences on the section output signal can be compensated for by superimposing with the actuating signal.

Disturbance variable compensation

The disturbance variable compensation is a procedure for reducing / removing the influence of a dominating (measurable) disturbance variable (e.g. external temperature) on the control circuit. A corrective operation is derived from the measured disturbance variable DISV, so that changes to the DISV can be reacted to more quickly. In the ideal case scenario, the influence is fully compensated for without the controller itself having to execute a corrective process (via the I part).

Fixed setpoint control

A fixed setpoint control is a control with a fixed, only rarely changing reference variable. Controls any disturbance variables that occur during the process.

Follow-up control

Follow-up control is a control where the reference value is constantly influenced from outside (underlaid controller of a multi-loop control). The task of the follow-up controller is to cover the local control variable with the reference variable as quickly and precisely as possible.

I part (integral component)

Integral component of the controller. After a jump-like change to the control variable (or negative deviation), the output variable changes ramp-like over the time, and at a rate of change that is proportionate to the integrated gain KI (= 1/TI). In a closed control loop the integral part adjusts the controller output variable until the negative deviation becomes zero.

Limit alarm monitor

Algorithm (function) for monitoring an analog variable for four specified limits. When reaching or exceeding / falling short of these limits, an associated warning (1st limit) or alarm signal (2nd limit) is generated. To prevent signal flicker the disable threshold (switch-back difference) of the limit signals can be set via a parameter for the hysteresis.

Limiter

Algorithm (function) for restricting the value range of constant variables to specified lower / upper limit values.

Manipulated value correction

The manipulated value correction prevents a step change at the manipulated value during the changeover from manual to automatic mode. The manipulated value remains unchanged during the changeover from manual to automatic mode.

Manipulated variable

The manipulated variable is the output variable of the controller or input variable of the control section. The actuating signal can portray the range of the manipulated variable analogously as a percentage or as a impulse value or pulse width. With integrated actuators (e.g. motor) it is sufficient to provide binary upwards / downwards or forwards / backwards switching signals.

Mixing control

The mixing control is a control structure whereby the setpoint for the entire quantity SP is calculated as a percentage of the desired number of parts of the individual controlled components. The total of the mixing factors FAC must be 1 (= 100%).

Negative deviation

The negative deviation is a function to form the negative deviation ER = SP-PV. At the reference junction, the difference between the desired setpoint and the actual existing process value is formed. This value is transmitted to the control algorithm as an input. Old description: Control deviation.

P controller (P algorithm)

Algorithm for calculating an output signal whereby characteristics exist with a proportionate connection between the negative deviation and the change in manipulated variable: remaining negative deviation, not to be used on dead time sections.

Parallel structure

The parallel structure is a special kind of signal processing in the controller (type of mathematical processing). The P, I and D parts are calculated as interaction-free and parallel and are then added up.

Physical standardization

→ standardization

PI controller (PI algorithm)

Algorithm for calculating an output signal where the change to the manipulated variable is made up from a part proportionate to the negative deviation and from an I part which is proportionate to the value of the negative deviation and the time. Features: no remaining negative deviation, quicker controlling than that with the I controller, suitable for all sections.

PID controller (PID algorithm)

Algorithm for calculating an output signal that is formed by the multiplication, integration and differentiation of the negative deviation. The PID algorithm is designed as a purely parallel structure. Feature: greater quality of control can be achieved, provided the dead time of the control section is not greater than the total of the remaining time constants.

Process identification

The process identification is a function of the configuration tool. It provides information regarding the transmission behavior and the structure of the process. A device-independent process model is conveyed as a result - this describes the process in its static and dynamic behavior. Optimum values for the controller parameters are calculated from this (controller design).

Process value

The current value of the control variable is PV

Ratio control

- single-loop ratio control

A single-loop ratio control is employed if the ratio of two control variables is more important for a process than the absolute values of the control variables (e.g. speed regulation).

- multiple-loop ratio control

  With a multiple-loop ratio control the relationship of the two process variables PV1 and PV2 is kept constant. To do this, the setpoint of the 2nd control circuit is calculated from the control variable of the 1st control circuit. Even with a dynamic change to the process variable PV1 it is ensured that the specified relationship is maintained.

Reference variable

The reference variable specifies the desired value or course of the process variables of interest. Your current value is → setpoint (SP).

Section

→ control section

Setpoint

The setpoint is the value that the control variable should adopt from the effects of a controller.

Square root

→ square root extraction

Square root extraction

With the square root function SQRT quadratic associations can be linearized.

Standardization

The standardization is a procedure (algorithm) for converting (standardizing) the physical values of a process variable into the (internally processed) percentage value of the control and then converting the other way round to the output. The standardization line is established by the start value and the end value.

Step and pulse controller

The step and pulse controller is a virtually constant controller with two binary output signals. The step controller serves to drive the integrated elements (e.g. step motor for opening and closing a valve). The pulse controller serves to drive the non-integrated elements (e.g. switching a heating on or off).

Three step controller

Controller with which the output variable can accept only three discreet states: e.g. "hot - off - cool" or "right - standstill - left."

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